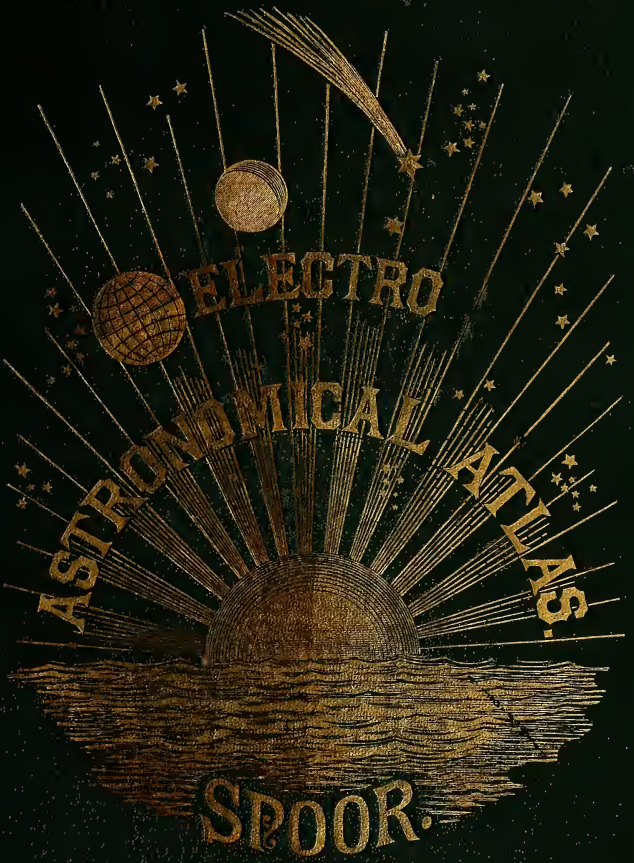

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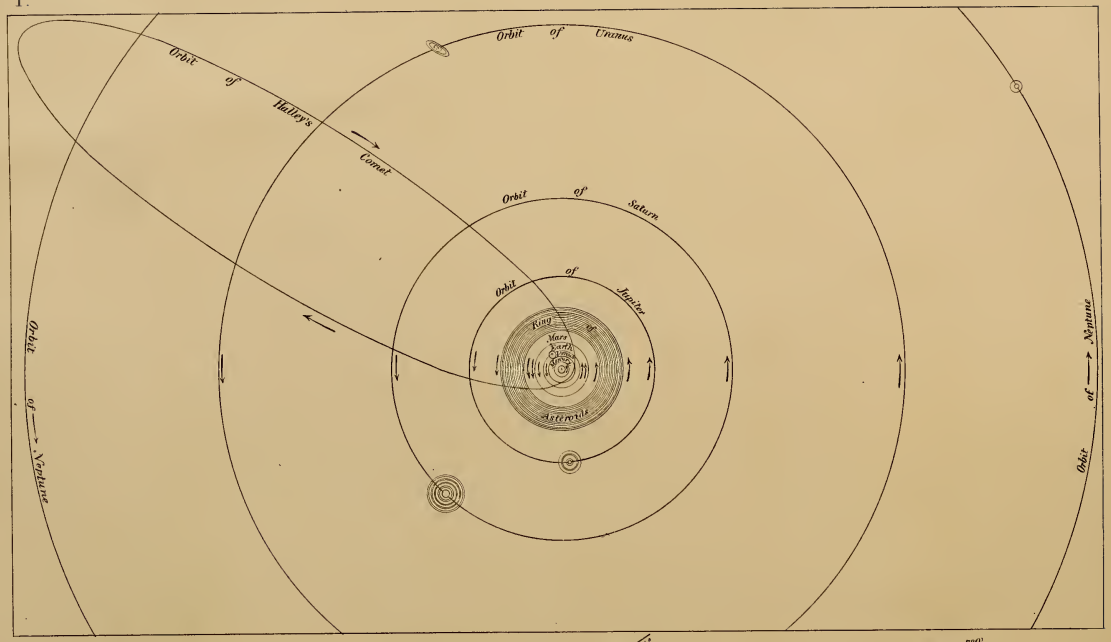

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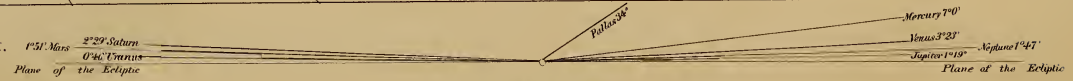

THE SOLAR SYSTEM.

I. Birds eye view of the Orbits. II. Inclinations of the Orbits.

ELECTRO
ASTRONOMICAL ATLAS,

DESIGNED FOR

SCHOOLS, ACADEMIES AND LADIES' SEMINARIES,

WITH

EXPLANATORY NOTES, QUESTIONS AND ANSWERS.

BY REV. J. W. SPOOR, A. M.

ROCHESTER, N. Y.

FULLY ILLUSTRATED.

9962 8

"THE HEAVENS DECLARE THE GLORY OF GOD, AND THE FIRMAMENT SHOWETH HIS HANDIWORK, DAY UNTO DAY UTTERETH SPEECH, AND NIGHT UNTO NIGHT SHOWETH KNOWLEDGE."—PSA. XIX: 1.

ALBANY, N. Y.
WEED, PARSONS AND COMPANY, PUBLISHERS,
1874.

Entered, according to act of Congress, in the year eighteen hundred and seventy-three,

By the Author,

JOSEPH W. SPOOR, A. M.,

in the office of the Librarian of Congress, at Washington.

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PREFACE.

The design of the author in presenting this work to the public is: To meet a great want in giving instruction in the interesting science of Electrical as well as Physical Astronomy.

Hitherto, the knowledge of Astronomy has only been taught in our Universities, Colleges and High Schools, and in *them* in a very limited manner, hence, those in our public schools have been entirely deprived of all knowledge of this useful branch of education.

Teachers of public schools have heretofore felt great embarrassment on introducing this branch of instruction in such schools, because of their incompetency to impart instruction to their pupils in the science, hence their objection to its introduction. This objection is entirely removed in presenting this work. It not only presents to the teachers an easy method of gaining instruction in the science, but an easy and pleasing way of imparting the same to their pupils.

It is the purpose of the author to present to the public an *elementary* work, and to bring this instruction within the reach of children from twelve to sixteen years of age, and so simplify and arrange it, that they can learn it as easily as they can learn Geography.

He has also adopted the *catechetical* form of instruction as a more popular method than the *topical*, because better adapted to their youthful comprehension, and they can the more easily retain the knowledge sought.

Some years since, he constructed and designed to publish a Diagram of the Solar System, to aid in the instruction of this science, for which the highest commendations were given by some of the most Scientific and Learned in the Universities and Colleges in this country.

This Diagram is pronounced the best of any yet exhibited to the public, from the fact that it is the only one that presents the *whole* Solar System to the eye at one view, and represents the orbits according to the true scientific angles by which they cross the plane of the Ecliptic.

The author is happy to announce that this Diagram is published and may be found in the front portion of the Atlas, and a description of it and its uses accompanies its introduction.

The author, having for many years investigated the laws of Electricity, and finding them intimately connected with Astronomy, in the evolutions of the Planets, hopes to be able to throw attractions around the study of Astronomy which will not fail to interest the lovers of science as much in this as in any branch of education ever presented to the scientific world.

He claims for this work a set of Diagrams and Illustrations exhibiting the most recent discoveries and observations made in this science down to the present time.

The progress of Astronomy is so rapid that almost all Text-Books are behind in this particular.

With these intentions and observations the work is published and presented to the public.

In preparing this work the Author has also freely consulted the following works among others: "Mitchell," "Guillemin," "Schellen," "Brewster," "Burritt."

AUTHOR.

A DIAGRAM

REPRESENTING AN OBLIQUE VIEW

TABULAR VIEW OF THE SOLAR SYSTEM.

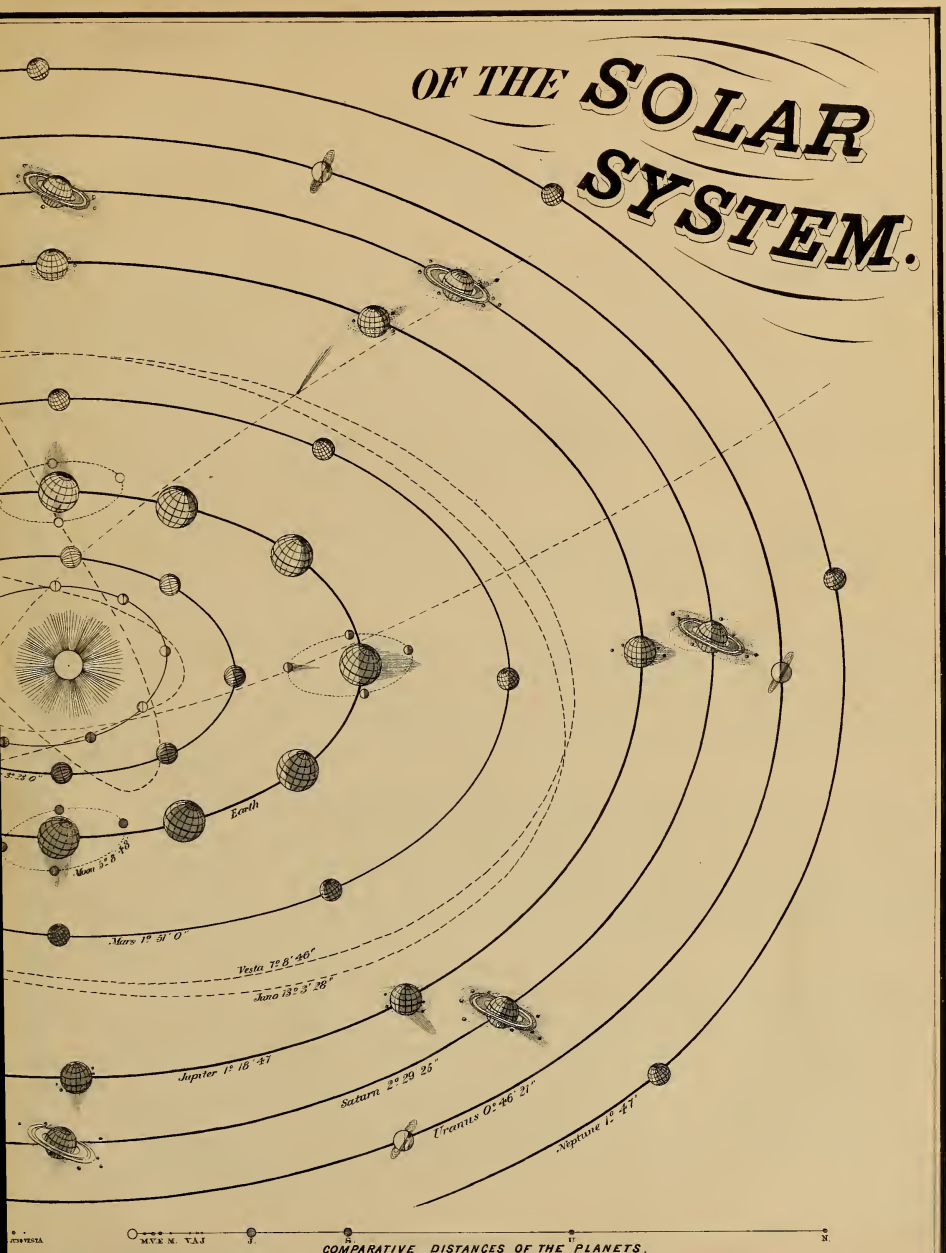
	Signs	Mean Diameter	Magnitude Earth being 1	Perihelion Distance	Aphelion Distance	Mean Distance	Density compared with Earth	Revolution round the SUN.	Inclination of the Orbit with the Ecliptic	Time of Diurnal Rotation	Inclination of Axis to orbit	Sidereal Period	Synodic Period
SUN	☉	882,000	1,000,000				1.42			25 d. 8 h.			
MOON	☾	2,160				238,000	3.44			27 d. 7 h. 43 m.			
MERCURY	☿	2,960	.063	39,000,000	42,000,000	35,400,000	6.69	88 d.	6° 59′ 30″	24 h. 5 m.	28°	87 d. 23 h. 15 m.	116 d. 18 h.
VENUS	♀	7,510	.883	65,000,000	69,000,000	66,130,000	3.84	224 d.	3° 23′ 30″	23 h. 21 m.	75°	224 d. 16 h. 49 m.	584 d. 0 h.
EARTH	⊕	7,970	1	90,000,000	95,000,000	91,904,000	5.67	1 y.	0° 0′ 0″	23 h. 56 m.	23° 28′ 0″	365 d. 6 h.	
MARS	♂	4,300	.118	126,500,000	132,500,000	130,000,000	3.97	1 y. 322 d.	1° 51′ 0″	24 h. 39 m. 21 s.	28° 42′ 0″	1 y. 322 d. 0 h.	780 d. 0 h.
CERES	⚳	1,000				221,000,000		4. 220 d.	10° 37′ 30″			4. 220 d.	
PALLAS	⚴	2,100				260,000,000		4. 220 d.	34° 45′			4. 220 d.	
JUNO	⚵	1,500				253,000,000		4. 131 d.	13° 1′			4. 131 d.	
VESTA	⚶	270				243,000,000		3. 229 d.	7° 8′			3. 229 d.	
JUPITER	♃	95,000	300.	453,000,000	493,000,000	490,000,000	1.37	11. 315 d.	1° 19′ 0″	9 h. 55 m.	3° 6′ 0″	11. 315 d.	399 d. 0 h.
SATURN	♄	80,000	87.2	833,000,000	930,000,000	885,000,000	.74	29. 167 d.	2° 30′ 0″	10 h. 29 m.	26° 40′ 0″	29. 167 d.	378 d. 0 h.
URANUS	♅	33,342	17.440	1,820,000,000	1,850,000,000	1,840,000,000	.92	84. 6 d.	46° 30′ 0″			84. 0 d.	369 d. 0 h.
NEPTUNE	♆	36,800	2.740	2,770,000,000	2,800,000,000	2,800,000,000	.91	165.	1° 30′ 0″			164. 226 d.	367 d. 0 h.

COMPARATIVE

MAGNITUDES

OF THE PLANETS.

OF THE SOLAR SYSTEM.



COMPARATIVE DISTANCES OF THE PLANETS.

Lith. by Weed, Parsons & Co. Albany, N.Y.

INTRODUCTION.

Accompanying this work is a Diagram, which, at the time of recitation, when necessary, can be spread open before the pupils that they may the more clearly apprehend the instruction imparted by it. A description of its design and use will now be given:

The object of this is to aid the teacher the more clearly to illustrate, and the scholar the more easily to apprehend the instruction to be received of this interesting science.

The Planetary System embraces the Sun, the Planets which move around him in their respective orbits, the Satellites or Moons connected with their respective primaries, together with the Asteroids and Comets. The Diagram exhibits at *one* view and in an oblique form this entire structure of the Solar System.

Other Solar charts now in use present only parts of this System to the eye at the same time, and represent the orbits as lying on the same plane and in true circles, and give a very imperfect view of the manner in which the Planets are enlightened by the Sun during the different months of the year.

The design of this Diagram more particularly is to exhibit and explain the true cause and philosophy of equal Day and Night; of the changes of the Seasons; why we have a difference in the length of Day and Night; the evident cause of the Eclipses, both Solar and Lunar; what produces the changes of the Moon, or, in other words, why we behold the Moon assuming so many different phases; and gives a comprehensive view of the movements of the heavenly bodies.

The Diagram also represents the Sun as the grand common center around which all the Planets move in their respective orbits, at different distances from the Sun, and the inclination of their axes. It also represents the Moon and Secondaries in their orbits, as they are moving around their respective primaries; and represents all as having their enlightened sides turned toward the Sun, their great central luminary. It represents, also, the relative magnitude of the planets, and their comparative distances from the Sun. It shows the elongated orbits of the Comets—their respective nodes and longitudes.

There is also a tabular view showing the distance of each planet from the Sun; the diameter of each planet and its time around the Sun representing the length of its year; the time required to revolve around its axis, showing the length of its day; the inclination their orbits make to the Ecliptic; the inclination of their axes to their own orbits; their density and the eccentricity of their orbits, and the difference in their Polar and Equatorial diameters.

Having given the design of the accompanying Diagram, I will proceed to give a description of the several parts explanatory of the principles it is designed to teach, with suitable questions and answers.

TESTIMONIALS.

UNIVERSITY OF ROCHESTER, N. Y.

January 6th, 1861.

I have examined with much interest and pleasure a Diagram of the Solar System, exhibited by Dr. J. W. SPOOR, of this city. It is one of the best I have ever seen, and when the modifications which he proposes to make are perfected it will be the very best. It will greatly aid the young student of Astronomy in forming a just conception of the order and arrangement of the bodies of our system, and will give him a tolerably good idea of the physical peculiarities of each body.

J. F. QUINBY,
Prof. of Math. and Nat. Phil.

UNIVERSITY OF ROCHESTER,

January 7th, 1862.

As an improved means of communicating important knowledge and of diffusing it among the people, the Diagram of the Solar System, by Dr. SPOOR, deserves high commendation. I gladly unite in the judicious statement of Prof. Quinby, and cordially commend it to the schools and their teachers and to the people in general.

C. DEWEY,
Prof. of Chemistry.

MADISON UNIVERSITY,

November 15th, 1861.

Dr. J. W. SPOOR has exhibited to us, to-day, a Diagram of the Solar System, which he is about to publish for the use of institutions of learning, especially of Common Schools, Academies and Ladies' Seminaries. We have been much interested in the examination of the Diagram, and cannot hesitate in expressing our judgment that its plan and execution are, in several important respects, greatly superior to those of any Diagrams of the kind to which our attention has been called. It cannot fail to facilitate, in a high degree, the study of the very interesting branch of knowledge for whose illustration it is designed, materially aiding, as it must, the teacher in communicating correct notions, and the pupil in apprehending them, in respect to the characteristic and leading facts appertaining to our Solar System.

GEO. W. EATON.
Pres. of Madison University.

[Signed by every member of the Faculty.]

HAMILTON COLLEGE,

November 18th, 1861.

Dr. J. W. SPOOR:

DEAR SIR: I was pleased with your idea of preparing a Diagram of our Solar System for the use of schools. There can be no doubt but a good Diagram may be used with great advantage in acquiring elementary notions of Astronomy; it will assist both the teacher and the pupils. It is also obvious that a very great amount of valuable information can be brought within a very small compass; nearly the entire statistics of the Solar System may be presented on such a Diagram as you propose to publish. * * *

Yours, respectfully,
O. ROOT,
Prof. of Math. and Nat. Phil.

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ELECTRO-ASTRONOMICAL ATLAS.

DEFINITIONS.

LESSON I.

ANALYSIS. — Circle Defined — Circumference — Diameter — Arc — Radius — Degrees.

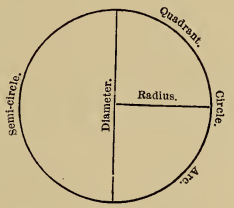


Fig. 1.

Q. What is a Circle? [See Fig. 1.]

A. A figure bounded by a curved line, every point of which is equally distant from the center.

Q. What is the circumference of a circle?

A. The curved line that bounds it.

Q. What is the diameter?

A. A line passing through the center of a circle, and terminated by the circumference.

Q. What is any part of the circumference called?

A. An Arc.

Q. What is the Radius?

A. A straight line drawn from the center to the circumference.

Q. How is the circumference of a circle divided?

A. Into 360 degrees.

Q. Into how many equal parts is a degree divided?

A. Sixty equal parts, called minutes.

LESSON II.

ANALYSIS. — Semi-Circles — Quadrant — Circles — Equator — Ecleptic — Tropics.

Q. What is a Semi-circle?

A. One-half of a circle, or 180 degrees.

Q. What is a Quadrant?

A. A quarter of a circle, or 90 degrees.

Q. How many kinds of circles are there?

A. Two: great and small.

Q. What is a great Circle?

A. A circle whose plane divides the sphere into two equal parts.

Q. What is a small Circle?

A. A circle whose plane divides the sphere into two unequal parts.

Q. Mention the principal great Circles?

A. Equator and Ecliptic.

Q. Mention the principal small Circles?

A. The Tropic of Cancer, the Tropic of Capricorn, and the two Polar Circles.

LESSON III.

ANALYSIS. — Lines : Curved, Straight, Parallel — Point — Surface — Ellipse — Its Diameter.

Q. What is a Line ?

A. It is that which has length without breadth or thickness.

Q. What is a Curved Line ?

A. One that continually changes its direction.

Q. What is a Straight Line ?

A. A line which has the same direction at every point.

Q. What are Parallel Lines ?

A. Lines that extend in the same direction, and are at the same distance from each other at all points.

Q. What is a Point ?

A. It is that which is conceived to have neither length, breadth or thickness, but position only.

Q. What is a Surface ?

A. It is that which has two dimensions — length and breadth.

Q. What is an Ellipse ?

A. It is a figure bounded by a curve, from any point of which, if straight lines be drawn to two fixed points within, called the Foci, the sum of these lines will be the same.

Q. What is the longest diameter of an Ellipse called ?

A. Major Axis.

Q. What is the shortest diameter called ?

A. Minor Axis.

LESSON IV.

ANALYSIS. — Angles : Right, Acute, Obtuse — Triangle.

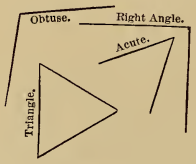


Fig. 2.

Q. What is an Angle ? [See Fig. 2.]

A. The opening of two lines that meet in a point.

Q. Name the different kinds of Angles ?

A. Right, Acute, and Obtuse.

Q. What is a Right Angle ?

A. An angle formed by a straight line meeting a perpendicular line.

Q. What is an Acute Angle ?

A. An angle less than a right angle.

Q. What is an Obtuse Angle.

A. One greater than a right angle.

Q. What is a Triangle ?

A. A figure bounded by three sides.

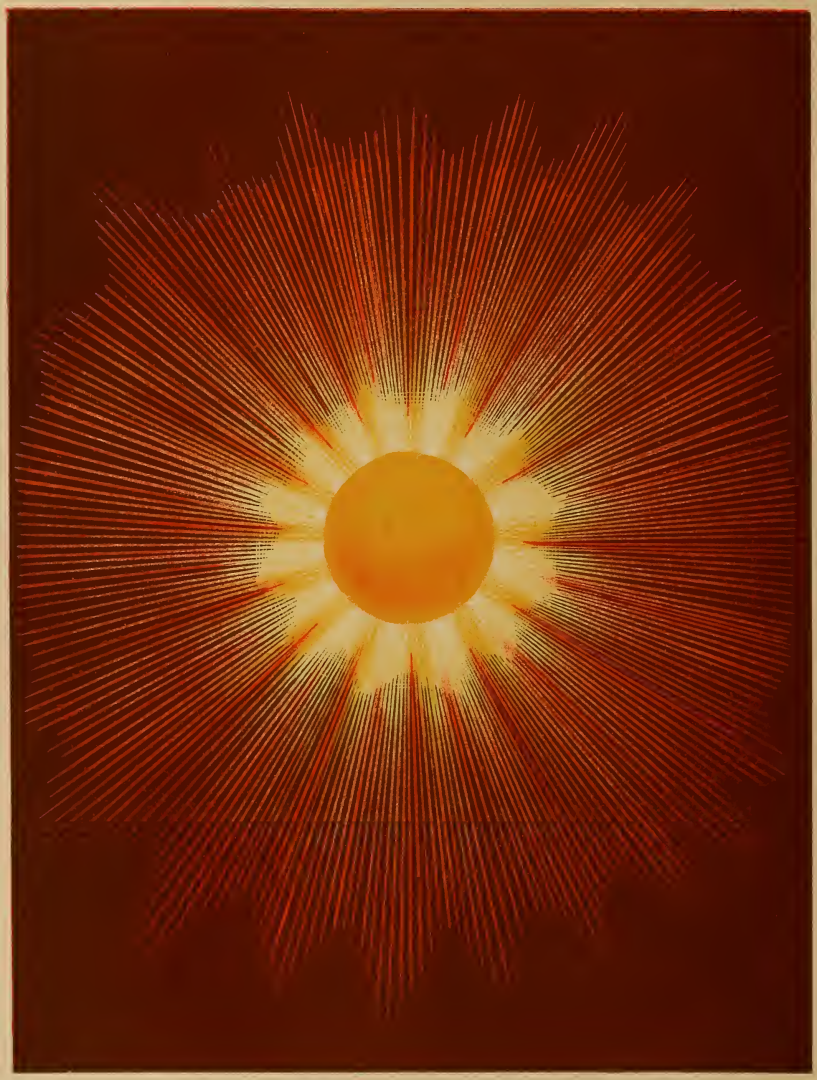
Q. What is a Sphere or Globe ?

A. A round body, every part of the surface being equally distant from a point within, called the center.

Q. What is a Hemisphere ?

A. Half a sphere, — hemi meaning half.

PLATE 1.



THE SUN.

LESSON V.

ANALYSIS. — Astronomy — Heavenly Bodies — Solar System — Sun — Size Compared with the Earth — Distance from the Earth — Terms Aphelion and Perihelion — Its Weight — How Known — Physical Nature — Appearance.

ASTRONOMY.

Q. What is Astronomy?

A. It is that branch of science which treats of the heavenly bodies.

Q. What are the names of the heavenly bodies?

A. The Sun, Planets, Satellites, Comets and Stars.

SOLAR SYSTEM.

Q. What is the Solar System?

A. The Solar System is composed of these heavenly bodies, moving in harmony round the Sun, as their common center.

Q. How many bodies are embraced in the Solar System?

A. There are one hundred and sixty-four.

Q. How are they divided?

A. There are the Sun, eight primary planets, twenty-one secondaries, and one hundred and thirty-four Asteroids, or Minor planets.

THE SUN.

Q. What is the Sun?

A. A vast, brilliant globe, around which the planets, their satellites, and comets revolve.

Q. What is the size of the Sun compared with the planets surrounding it?

A. The Sun is by far the largest of the heavenly bodies, being more than five hundred times as large as all the planets taken together.

Q. What is its magnitude when compared with that of the Earth?

A. The Sun is equal to 1,400,000 globes the size of the Earth.

Q. Can we form an adequate conception of its vast dimensions?

A. It is impossible for the human mind to form an idea of its vastness.

Q. What is the diameter of the Sun?

A. Its real diameter is 852,900 miles.

Q. What is the distance of the Sun from the Earth?

A. Recent investigations show the distance, when the Earth is in Aphelion, to be 93,000,000 miles; but when it is in Perihelion, it is 90,000,000 miles, the mean distance being 91,500,000 miles.

Q. What is meant by the term Aphelion?

A. That point of the orbit which is farthest from the Sun.

Q. What is meant by the term Perihelion:

A. That point which is nearest the Sun.

Q. How does the weight of the Sun compare with all the planets, satellites and comets of the Solar System?

A. About seven hundred and fifty times as heavy as all of them taken together.

Q. How do we ascertain its weight?

A. From the power of its attraction.

Q. What is known of the physical nature and constitution of the Sun?

A. Various are the theories of astronomers respecting its physical nature and constitution. The recent and most reliable hypothesis is, that the nucleus of the Sun is an incandescent solid or liquid mass.

Q. How does it appear to us when seen through a telescope?

A. It presents the appearance of an enormous globe of fire, frequently in a state of violent agitation or ebullition.

LESSON VI.

ANALYSIS. — Hypothesis — Element — Electricity — Its Discovery — By Whom — Diversity of its Operation.

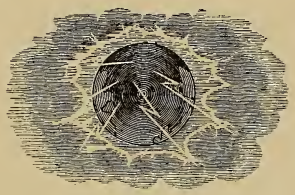


Fig. 8.

ELECTRICITY.

From the fact that the Sun is the source of all light, heat, and life in the realm of nature, and that light and heat are component parts of Electricity, therefore, the Hypothesis is entertained that the Sun is constituted with the all-pervading element Electricity.

Q. What element naturally flows out of the Sun? [See Fig. 3.]

A. Electricity.

Q. What is Electricity?

A. Electricity is an imponderable fluid, emanating from the Sun.

Q. When and by whom was Electricity discovered?

A. It was discovered 600 years before the Christian era, by Thales, a celebrated Grecian sage of the city of Miletus in Ionia.

Q. How did he make the discovery?

A. He detected it in a substance called amber, which, in the original Greek, is called Electron, from which is derived the term Electricity.

Q. Is it derived from any other word?

A. Electricity is also derived from another Greek word, Electore, which signifies "beaming sun."

Remark.—This seems to indicate that the ancients supposed the Sun to be the fountain of this subtle fluid.

Q. What led him to make the discovery?

A. He ascertained that the amber, when rubbed, acquired the power of attracting to itself certain light bodies surrounding it.

Q. How can this interesting phenomenon be illustrated by the student without this amber?

A. By taking a stick of sealing wax and brushing it briskly with a piece of silk, or woolen cloth, and passing it over small pieces of paper.

Q. Is Electricity uniform in its manifestation?

A. Infinite wisdom has constituted Electricity a mighty agent, in various ways, his "wonders to perform."

Q. In what manner more particularly is it revealed?

A. It is not simply manifest in the thunderbolt, but in the agitative power of galvanism; in the permeating influence of magnetism; in a universal flood of light, and in the all-pervading manifestations of heat.

Q. What are other modified representations of this same imponderable principle?

A. The attraction of gravitation and cohesion.

LESSON VII.

ANALYSIS. — Sun — Relation to the Solar System — Its Electrical Power — Developed in Attraction and Repulsion — Position Confirmed by R. A. Proctor and Other Eminent Astronomers — Pervading of all Things by Electricity.

RELATION OF THE SUN TO THE SOLAR SYSTEM.

Q. What relation does the Sun hold to the entire Solar System?

A. The Sun is the great fountain of electricity, from which emanates, as from a galvanic battery, all the power necessary, under the established

electrical laws of attraction and repulsion * to govern the motion of the planets in their diurnal and annual revolution around the Sun.

Q. What other principle does it produce?

A. It produces the vivifying principle of both animal and vegetable life, all chemical changes in the realm of nature, and is the active and efficient agent, both in decomposition and recomposition of the organic structure of men and animals.

Q. Is there any part of the Solar System in which this principle is not manifest?

A. There is no department of the entire Solar System in which this imponderable principle does not exert a quickening and controlling influence or power.

* In a letter written the *N. Y. Herald*, from Cleveland, O., Jan. 28, 1874, Richard A. Proctor holds this language on the evolution of the earth: "During all these years, she has been gathering up a few . . . . chips scattered about the mighty workshop in which the giant workmen *Attraction* and *Repulsion* had fashioned the Solar System." Other eminent astronomers have recently confirmed me in my position as to the law of Attraction and Repulsion governing the planetary world.

Q. Is this element all-pervading in its influence?

A. It permeates every thing — from the largest planet, Jupiter, to the smallest particle of sand upon the sea shore.

Remark. — What Pope said of the Divine essence is as truly said of this all-pervading principle:

"It warms in the sun,
Refreshes in the breeze,
Glows in the stars,
And blossoms in the trees;
Lives through all life,
Extends through all extent,
Spreads undivided,
And operates unspent."

NOTE. — We should never lose sight for a moment of the great self-existent principle we call Deity, whose Attributes are Omniscience, Omnipresence, Omnipotence and Eternity; who created all things, and established the universe, composed probably of hundreds of solar systems like our own, and sent them spinning through infinite space, balanced and controlled in perfect harmony, under those electrical laws by which He governs all things in His vast and infinite domain.

LESSON VIII.

ANALYSIS. — Sun's Motion — Time Revolution — How know it Revolves — Its Axis — Spots on its Disc — Accounted For — Drummond Light Compared with the Sun.

MOTION OF THE SUN.

Q. In what time does the Sun revolve on its axis?

A. Twenty-five days, eight hours and nine minutes.

Q. What proof have we that the Sun turns on its axis?

A. By the motion of certain dark spots on its disc.

Q. What is the axis of the Sun?

A. An imaginary line on which it revolves.

Q. What is meant by the disc of a body?

A. The circular illuminated surface.

Dark Spots on the Sun.

Q. When and by whom were the dark spots on the disc of the Sun discovered?

A. By Galileo in the beginning of the year 1611.

Q. Since that time has the Sun always presented a spotted disc?

A. From the year 1676 to the year 1684 the Sun presented an unspotted disc.

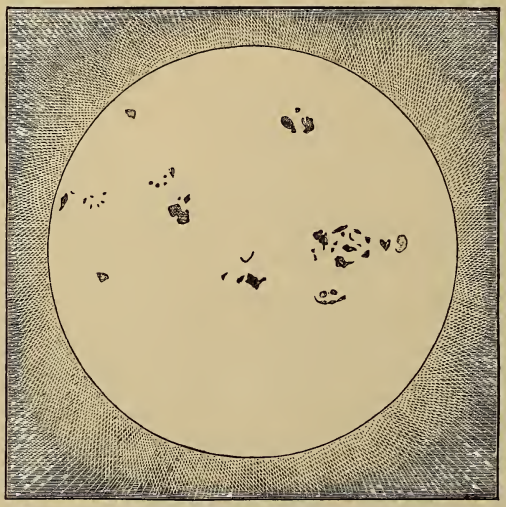


Fig. 4.

Q. Do they always take the same direction over the Sun's disc?

A. They do not. Sometimes they seem to move across it in straight lines; at others, in curved lines. Sometimes upward, as they cross from east to west; at others, they incline downward.

Q. What causes these changes?

A. They are owing to the fact that the axis of the Sun is inclined to the Ecliptic; so that as we view the Sun from different points in the earth's orbit, the direction of the spots must necessarily vary.

The following diagram will serve to illustrate this:

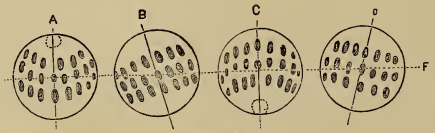


Fig. 5.

The annexed diagram will still further illustrate the cause of the change of direction of the solar spots:

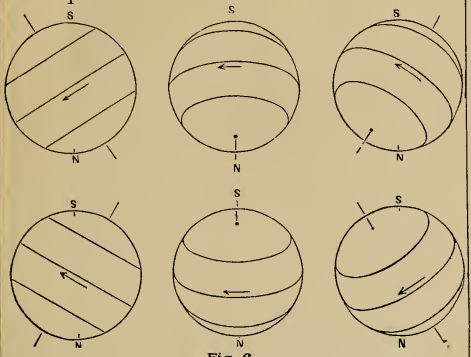


Fig. 6.

Q. How are the spots on the disc accounted for?

A. The atmospheres surrounding the Sun, being made up of the bright scintillations of electricity, which radiate from within, become so exceedingly brilliant and luminous, that when at any time an opening appears in them, and the main body is seen, though incandescent, yet in contrast with the dazzling corruscations surrounding it, the nucleus, or mass, appears in spots, dark and opaque.

The forms of the spots, as shown by the drawings placed before the reader, are most varied. The penumbra most frequently reproduces the principal contours of the umbra, and often presents a great variety of shades, when examined with considerable magnifying powers. On the exterior edges of the penumbra, the grey tint seems generally the deepest, either by the effect of contrast with the brilliant portions that surround it, or because in reality it possesses at these points a more decided tint.

Fig. 7 affords a striking example of this aspect of the penumbra.

This spot presents the peculiarity, not at all unfrequent, that the dark umbra is divided into several fragments by luminous bridges, spanning it, as it were, from one side of the penumbra to the other.

The umbra itself is far from offering an uniform black tint. In reality it always presents the appearance of varied shades, as if the penumbra and umbra were mingled, and mixed up their tints in varied proportions.

[We owe to the Rev. W. R. Dawes the discovery that the *umbra* is but a darker kind of penumbra; for under the best conditions of air and instrument, he has found within some umbræ a much darker portion — which he calls the *nucleus*. This he finds to be of the most intense blackness; but in saying this we must warn our readers that such a word as applied to the Sun is comparative only. Sir J. Herschel has shown

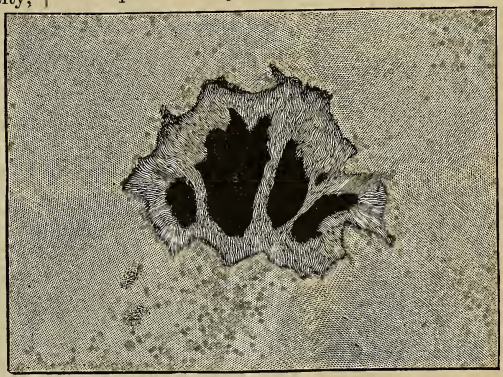


Fig. 7. — WILLOW LEAF.
Sun-spots, showing Umbra, Penumbra, and Luminous Bridges. (Nasmyth.)]

that a ball of ignited quicklime, in a Drummond's oxyhydrogen lamp, which itself gives out an

apparently near approach to sunlight, when projected on the Sun *appears as a black spot.* So that the Sun-spots, properly so called, may not be so black after all !]

The transits of Mercury, moreover, over the Sun's disc have taught us that the umbra is less dark than the unilluminated face of a planet.

We shall now speak of the real dimensions of the spots, the successive changes which they undergo, and what astronomers call their "proper motion," that is, their actual movement on the Sun's surface in any direction.

Q. What effect do you say these exceedingly bright scintillations of electricity have upon the appearance of the nucleus of the Sun ?

A. When these openings are made, the mass or body of the Sun, although under the most vivid incandescence, appears dark in comparison to the luminous envelope which surrounds it.

Q. How does the most brilliant light of which we have any knowledge compare with the light of the Sun ?

A. The Drummond light, the most powerful, when held between our vision and the Sun, presents a dark spot.

If we imagine that on the surface of the dark nucleus there are formed from time to time gaseous masses, incandescent by reason of their high temperature; or again, if there exist on the same surface centers of volcanic disturbance, the eruptions proceeding from these craters, piercing and tearing away successively the two interior atmospheres of the Sun, would produce holes of the greater or less extent, openings through which the central nucleus or the overlying umbra could be seen. These openings, therefore, should present generally the form of an irregular cone, widened at the upper part, exposing at its center the solid and obscure part of the Sun, and all around this the cloudy atmosphere of a greyish tint. Hence, black spots, surrounded with penumbra.

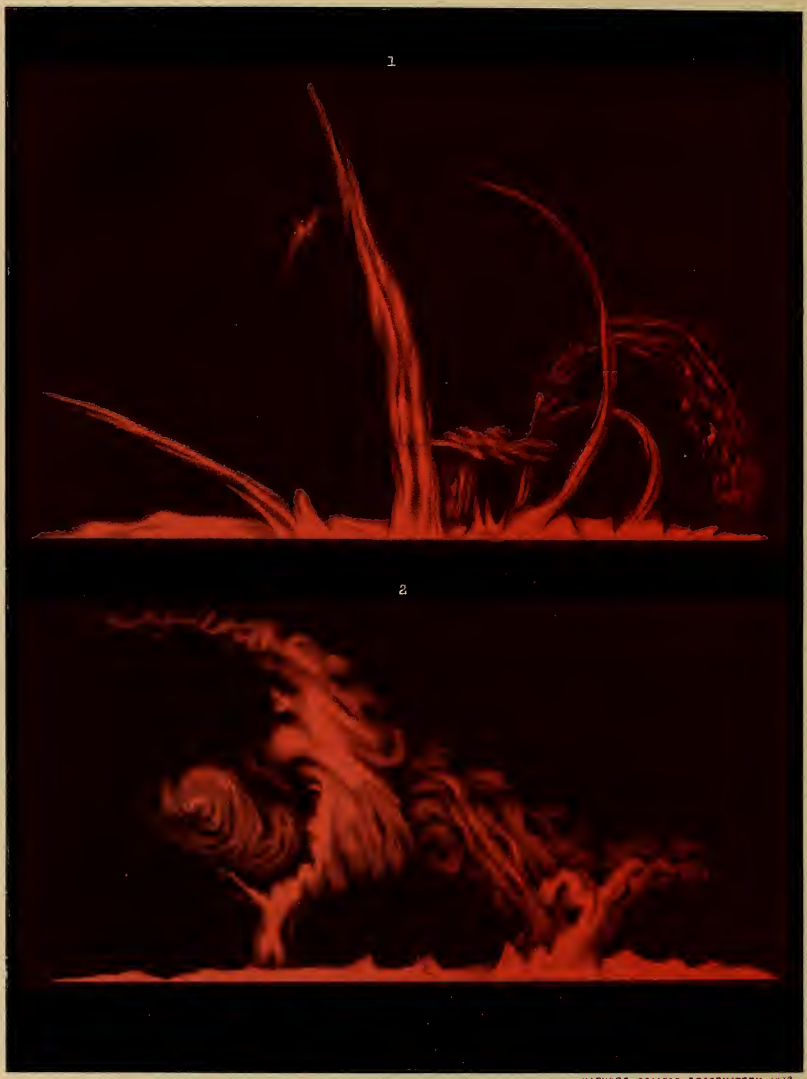
The Sun revolving on its axis brings a spot nearer to the center, hence gives us a more direct view of the opening, and we discover more of the dark body. Again, the nucleus will disappear as it passes by the center, until we only can see the side of the opening, and in a short time the penumbra will also pass from our view.

Fig. 8.

Explanation of sun-spots on Wilson's hypothesis : *a a*, photosphere ; *b b*, cloudy stratum ; A, spot with nucleus (umbra) and penumbra ; B, nucleus (umbra without penumbra) ; C, penumbra without nucleus (umbra).

But it may happen that the opening thus made in the photosphere will be smaller than that in the cloudy stratum. In this case the black nucleus will be alone visible, and it is thus that a spot without penumbra is explained. If, on the contrary, the rupture in the first envelope closes up before the photosphere, then the obscure body will be invisible, a circumstance which easily explains penumbra without a nucleus.

PLATE II.

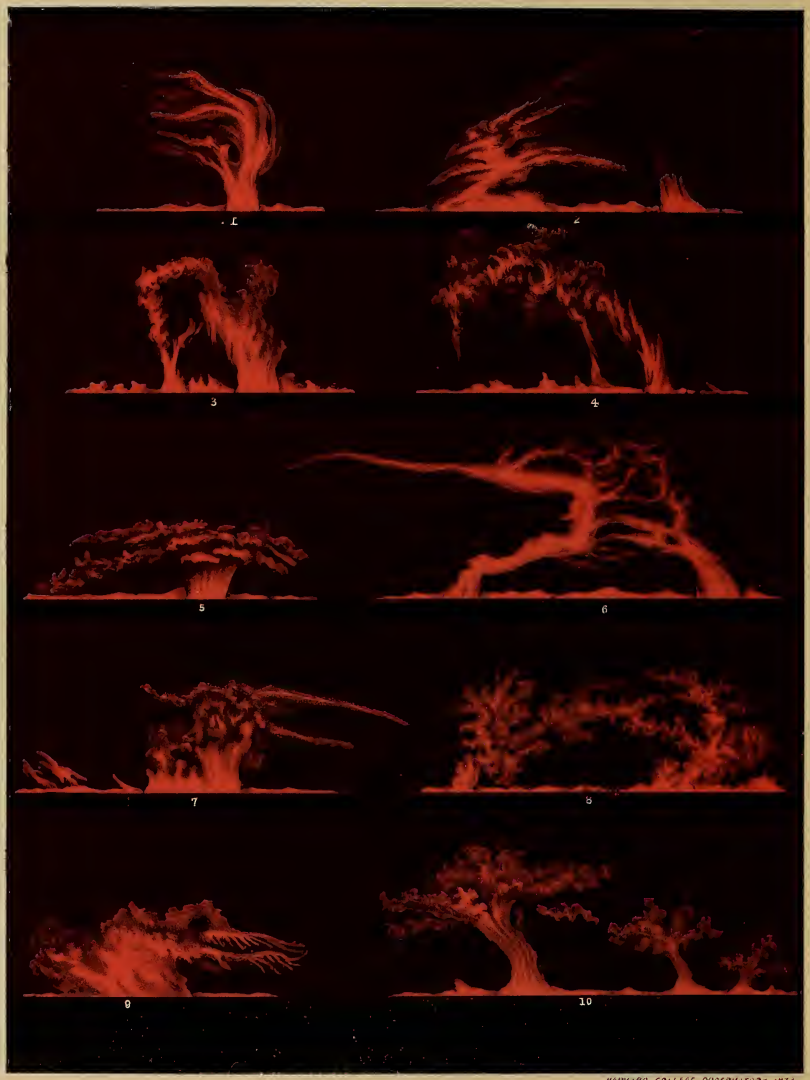


HARVARD COLLEGE OBSERVATORY 1872

SOLAR PROMINENCES.

English miles 10 20 30 40 50 60 70 80 90 100,000

PLATE III.



HARVARD COLLEGE OBSERVATORY 1872.

SOLAR PROMINENCES

English miles 0 10 20 30 40 50 60,000

LESSON IX.

Analysis. — Solar Prominences — Time of Appearance — Production — Duration — Height — Appearance of Jets — Scenes from Harvard College — Spots — Passage over Disc — Appearance — Uniform Time.

Solar Prominences.

Q. What phenomenon is often revealed when a total eclipse of the Sun occurs?

A. There are manifest certain solar prominences.

Q. What is the general appearance of the solar prominences?

A. They originate in brilliant jets, either vertical or oblique.

Q. How are these solar prominences produced?

A. They are produced by incandescent molecules, or emanations of the electrical element from the Sun.

Q. How long do they remain?

A. There is a great difference in their duration; sometimes they remain only a few moments; at others, they continue for several days.

Q. To how great an elevation do these often arise?

A. Sometimes to the height of eighty thousand miles.

Q. What is there peculiarly interesting in these illustrations?

A. The varied appearance of these brilliant jets, some straight, some oblique, and others rising and then falling again on the Sun, like jets of our fountains. — See plates II and III.

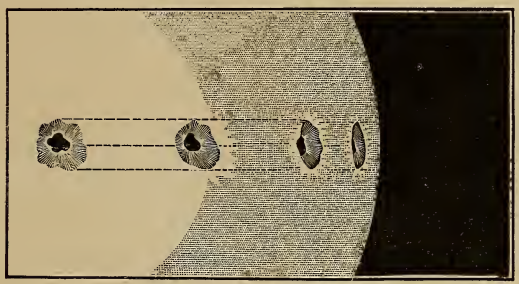


Fig. 9.

Q. Which way do these spots pass over the disc of the sun?

A. They pass from east to west.

Q. In illustration (Fig. No. 9), describe the form of the spot just entering upon the sun's disc.

A. It appears oval in form, the greatest length being at right angles to its motion across the sun.

Q. Does its form continue the same?

A. In proportion as the spot approaches the centre, it widens, so that it becomes nearly circular, and as it passes off the western portion of the sun, it assumes the same forms, only reverse in the order.

Q. How long do these spots remain visible?

A. About fourteen days.

Q. Is this length of time ascribed to all of them?

A. Their time is usually uniform.

Remark.—So uniform is their time, that just fourteen days from the time the spot disappears on the western border, it again reappears on the eastern, often changed in form, it is true, but generally recognizable.

LESSON X.

ANALYSIS. — Dimensions — Compared to the Globe — Measurements of Schroeter — Of Sir W. Herschel — Of Captain Davis — Remark — Physical Organization of the Sun — Views of Sir W. Herschel — Of Kerchoff — Of Sir John Herschel — Why Vary in Appearance — Way the Sun Turns on its Axis — Do all the Planets and Constellations Turn the Same Way? — Evidence of their Revolution from West to East — Time of Revolution of Sun — Inclination to Ecliptic.

Q. Are the dimensions of the spots uniform?

A. They are extremely varied as to size.

Q. How will they compare to our globe?

A. It is not uncommon to see them with their surface larger than the earth.

Q. How extensive was one measured by Schroeter?

A. He measured one which was equivalent to sixteen times the surface embraced by a great circle of our Earth, or four times the entire superficies of our globe.

Q. How great was its diameter?

A. Nearly four times the diameter of the Earth, that is, more than twenty-nine thousand miles.

Q. What was the size of a spot measured by Sir W. Herschel?

A. It consisted of two parts, the diameter of which was not less than fifty thousand miles.

Q. How large were some observed by Captain Davis in 1839?

A. The most extensive was not less than one hundred and eighty-six thousand miles in its greatest length, and the surface embraced about 25,000,000,000 miles.

Remark.—The question as to what is the physical organization of the Sun is one on which astronomers have entertained various opinions, and to which they have failed, thus far, to give a satisfactory answer. The Sun appears to some to be surrounded by an ocean of inexhaustible flame, with dark spots of enormous size now and then floating on its surface.

Q. What views were entertained by Sir W. Herschel?

A. He supposed the Sun to be a solid, dark body, surrounded by a vast atmosphere, almost always filled with luminous clouds, occasionally opening, and disclosing the dark mass within.

Q. What are the views expressed by Kerchoff?

A. The idea entertained by him was, "that the Sun is an incandescent solid, or liquid mass," by which he means that its nucleus has the appearance of being *white* heated, the vapors of which form the atmospheres; the denser and lower one being luminous, from the incandescent particles that float into it.

Q. What were the views expressed by Sir John Herschel respecting the brilliant atmosphere enveloping the Sun?

A. He contended that the gaseous, brilliant, atmospheric representations arose from the electrical magnetism of the Sun.

Q. Why do the spots vary in their appearance?

A. The varied appearance of these spots depends upon the changes of temperature in these atmospheres, giving rise to tornadoes and other violent agitations. The descending currents produce the various openings which are dark, because filled with clouds of various condensation.

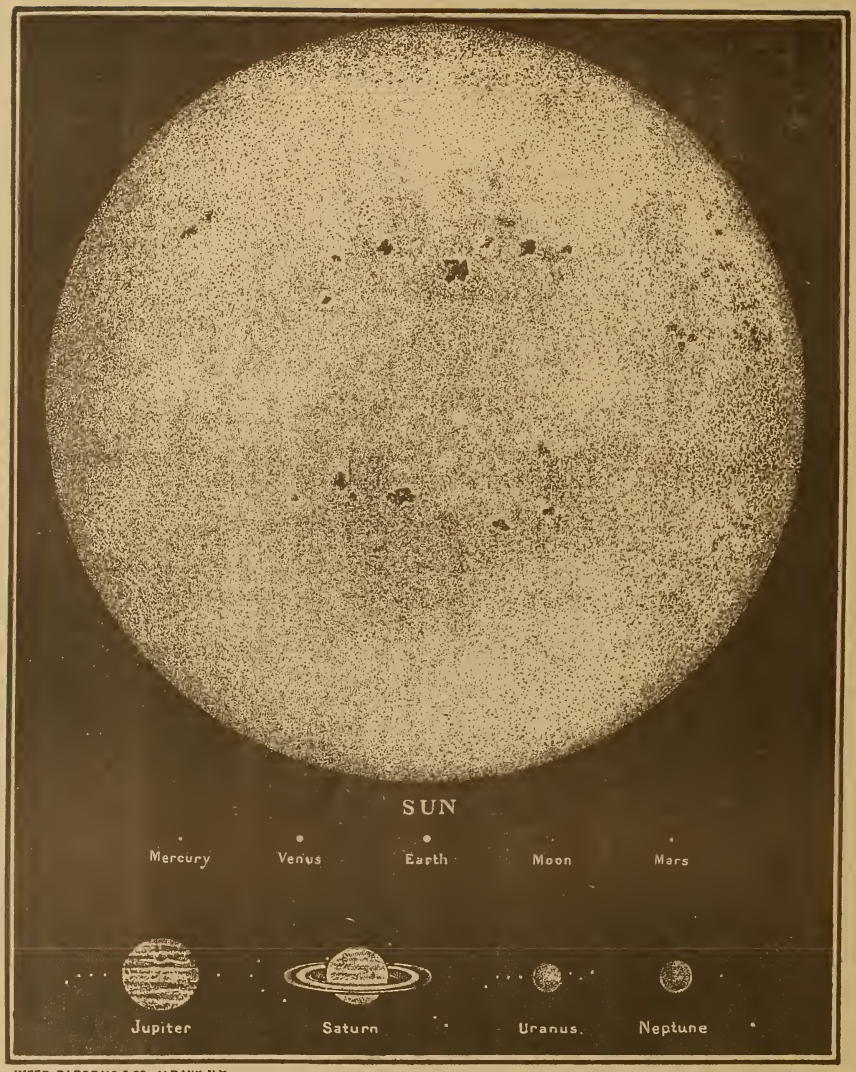
Q. In what direction does the Sun turn on its axis?

A. From west to east.

Q. Do all the planets and satellites revolve in the same direction?

A. All of them except the satellites of Uranus and Neptune; they revolve in the opposite direction.

PLATE IV.



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COMPARATIVE DIMENSIONS OF THE SUN, THE PLANETS AND THEIR SATELLITES.

Q. How is it evident that planets, etc., revolve from west to east?

A. By the order of the signs of the zodiac.

Q. How fast does the Sun revolve in its orbit?

A. At the rate of 14,400 miles in an hour.

Q. What is the inclination of the axis of the Sun to the Ecliptic?

A. Seven degrees and twenty minutes.

LESSON XI.

ANALYSIS. — Planets — Why thus Called — Division — Primary — Secondary — Equilibrium of Motion — Law of Attraction and Repulsion — Law Explained.

THE PLANETS.

Q. What are planets?

A. Dark bodies revolving around the Sun.

Q. From whence do they derive their name?

A. From the Greek word Planatis, meaning wanderer.

Q. Why was this term applied to these dark bodies?

A. Because they change their positions in the heavens, while the fixed stars maintain the same relative position.

Q. How are the planets divided?

A. Into primary and secondary planets.

Q. Mention the primary planets?

A. Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

Q. Why are they called primary planets?

A. Because they revolve around the Sun.

Q. Why are the others called secondary planets.

A. Because they revolve around their primaries, and with them around the Sun.

Q. How many secondary planets are there?

A. Twenty-two.

EQUILIBRIUM OF THE MOTION OF THE PLANETS.

All acknowledge that God created the planets and set them rolling in their respective orbits, and that he constituted certain laws, by which they are continued in their revolutions; hence we lay down the hypothesis, that they are continued in their revolutions by the electrical law of attraction and repulsion.

Q. How are these planets balanced and kept in their respective orbits?

A. By the immutable law of attraction and repulsion; in other words, by centripetal and centrifugal force.

Q. What is the origin or foundation of the law of attraction and repulsion?

A. This law has its origin in the electrical power the Sun exerts over the planets.

Explanation.—I. Two positives repel each other. II. A positive and a negative attract each other.

The Sun is the fountain of all electricity to the planetary system, therefore always positive in his nature.

The planet drawing near the Sun becomes positive, and is repulsed; receding from the Sun becomes negative, and is drawn again toward the Sun.

LESSON XII.

ANALYSIS. — Distribution of Secondary Planets — Interior Planets — Exterior — Their Conjunctions — How Shine — Distinguished From Stars.

DISTRIBUTION OF SECONDARY PLANETS.

Q. How are the secondary planets distributed among the primaries?

A. The Earth has one; Jupiter four; Saturn eight; Uranus eight, and Neptune one.

Q. What planets revolve within the orbit of the earth?

A. Mercury and Venus.

Q. What are they called?

A. Interior planets.

Q. What planets revolve without the orbit of the Earth?

A. Mars, Jupiter, Saturn, Uranus and Neptune.

Q. What are these planets called?

A. Exterior planets.

Q. Why is this distinction of qualification made?

A. Mercury and Venus are called interior because they are but a short distance from the Sun, and are seldom seen; and the other planets are called exterior because they are seen at all distances from the Sun.

Q. What are the planets lying without or beyond the orbit of the Earth called?

A. Exterior planets.

Q. How many conjunctions have they?

A. They have one conjunction and one opposition each.

Q. When are they in conjunction?

A. When they are beyond the Sun and in range with it and the Earth.

Q. When are they in opposition?

A. When in range with the Earth and Sun, and the Earth is between them and the Sun.

Q. What causes the planets to shine?

A. The reflection of light received from the Sun.

Q. How may they be distinguished from the stars?

A. Their light is steady, while the light of the stars appears to twinkle.

LESSON XIII.

ANALYSIS. — Apparent Motions of the Sun, What Called — How Caused — The Daily Phenomenon Connected with the Apparent Motions of the Sun — Changes in the Points of Rising and Setting — Point of Culmination — Solstices and Equinoxes — Note — Ecliptic — Coincidence with the Plane of the Earth's Orbit — Intersection of the Circle of the Celestial Sphere and the Orbit of the Earth — Obliquity of the Ecliptic.

APPARENT MOTIONS OF THE SUN.

Q. How many apparent motions around the Earth has the Sun?

A. He has two.

Q. What are they called?

A. They are diurnal and annual.

Q. Which way does he appear to revolve in his diurnal motion.

A. From west to east.

Q. Which way in his annual motion?

A. From east to west.

Q. How are these changes produced?

A. The diurnal motion is caused by the rotation of the earth on its axis, and the annual by the revolution of the earth around the Sun.

Q. How often, and at what seasons of the year does the Sun appear to rise exactly at the east point of the horizon and set at the west point?

A. Twice each year; about the 20th of March and the 23d of September.

Q. What is the meridian altitude of the Sun?

A. The highest point to which the Sun apparently rises above the horizon.

Q. During what time does the Sun's meridian altitude increase?

A. From March 20th till June 21st, and the points at which the Sun rises and sets move from the east and west toward the north.

Q. At what time of year does the meridian altitude of the Sun diminish?

A. From June 21st till September 23d, and meanwhile the points of rising and setting move back toward the east and west.

Q. Does the meridian altitude vary at other times in the year?

A. The points of the rising and setting of the Sun, from September 23d till December 22d, move toward the south, and the altitude decreases also from December 22d till the 20th of March, the points of rising and setting move backward toward the east and west, and the meridian altitude increases.

Q. At what points of time does the Sun seem to reach his culmination?

A. On the 21st of June and the 22d of December.

Q. What are these points called?

A. They are called solstices.

Q. What are the points at which the culmination of the Sun coincides with the celestial equator called?

A. They are called equinoxes.

Q. Why called equinoxes?

A. Because the days and nights are equal.

NOTE.—From this it is seen there is a constant movement of the points of rising and setting alternately from north to south, and a constant variation, up and down, of the point of culmination, except that the Sun culminates at the same altitude for several days, about the 21st of June and the 22d of December. These two stationary points of culmination are called the *solstices.*

Q. What is the Ecliptic?

A. It is the great circle of the celestial sphere in which the Sun appears to revolve around the Earth every year.

Q. How does the plane of the Ecliptic coincide with the plane of the Earth's orbit?

A. The great circle of the celestial sphere is intersected by the Earth's orbit.

Q. What is the inclination of the axis of the Earth to the plane of its orbit?

A. It is sixty-six and one-half degrees.

Q. Then at what point do the Ecliptic and equinoctial cross each other?

A. At an angle of twenty-three and one-half degrees.

OBLIQUITY OF THE ECLIPTIC.

The inclination of the Earth's axis to the plane of the Ecliptic causes the equinoctial to depart 23° 28′ from the Ecliptic. This angle made by the equinoctial and the Ecliptic is called the *Obliquity of the Ecliptic.*

Let the line A A represent the axis of the Earth, and B B the poles or axis of the Ecliptic. Now, if the line A A inclines toward the plane of the Ecliptic, or, in other words, departs from the line B B to the amount of 23° 28′, it is obvious that the plane of the equator, or equinoctial, will depart from the Ecliptic to the same amount. This departure, shown by the angles C C, constitute the *Obliquity of the Ecliptic.*

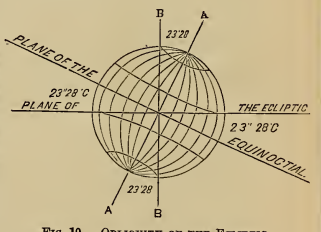


FIG. 10.—OBLIQUITY OF THE ECLIPTIC.

Hitherto, we have considered these great primary circles in the heavens as never varying their

position in space, nor with respect to each other. But it is a remarkable and well-ascertained fact that both are in a state of constant change. We have seen that the plane of the Earth's equator is constantly drawn out of place by the unequal attraction of the Sun and Moon acting in different directions upon the unequal masses of matter at the equator and the poles; whereby the intersection of the equator with the ecliptic is constantly retrograding — thus producing the *precession of the equinoxes.*

Q. What are the points opposite the Ecliptic where it crosses the equinoctial called?

A. They are called EQUINOCTIAL POINTS, or EQUINOXES.

Q. How are they distinguished?

A. The one which the Sun passes in March is called the VERNAL EQUINOX; that which it passes in September is called the AUTUMNAL EQUINOX.

Q. What are the two points opposite the Ecliptic, at which the Sun is farthest from the equinoctial, called?

A. They are called SOLSTITIAL POINTS, or SOLSTICES.

Q. How are they distinguished?

A. The one north of the equinoctial is called the *Summer Solstice;* the one south of it the *Winter Solstice.*

LESSON XIV.

ANALYSIS. — Mercury — Situation — Rate of Motion — Time of Revolution — Indications — Diameter — Inclination of Orbit to Plane of Ecliptic — Inclination of Axis — Time of Revolution on its Axis — Uniformity of Appearance.

MERCURY.

Q. Which is the nearest planet to the Sun?

A. Mercury.

Q. How far is it from the Sun?

A. Thirty-seven million miles.

Q. What is its rate of motion around the Sun?

A. One hundred and ten thousand miles an hour.

Q. How long does it take Mercury to make his flight around the sun?

A. Eighty-eight days.

Q. What does this indicate?

A. The length of his year.

Q. What is the real diameter of Mercury?

A. Two thousand nine hundred and fifty miles.

Q. What is the inclination of the plane of his orbit to the plane of the Ecliptic?

A. Seven degrees.

Q. What is the inclination of its axis to the plane of its orbit?

A. Seven and one-third degrees.

Q. How long does it take Mercury to turn on its axis?

A. Twenty-four hours and six minutes.

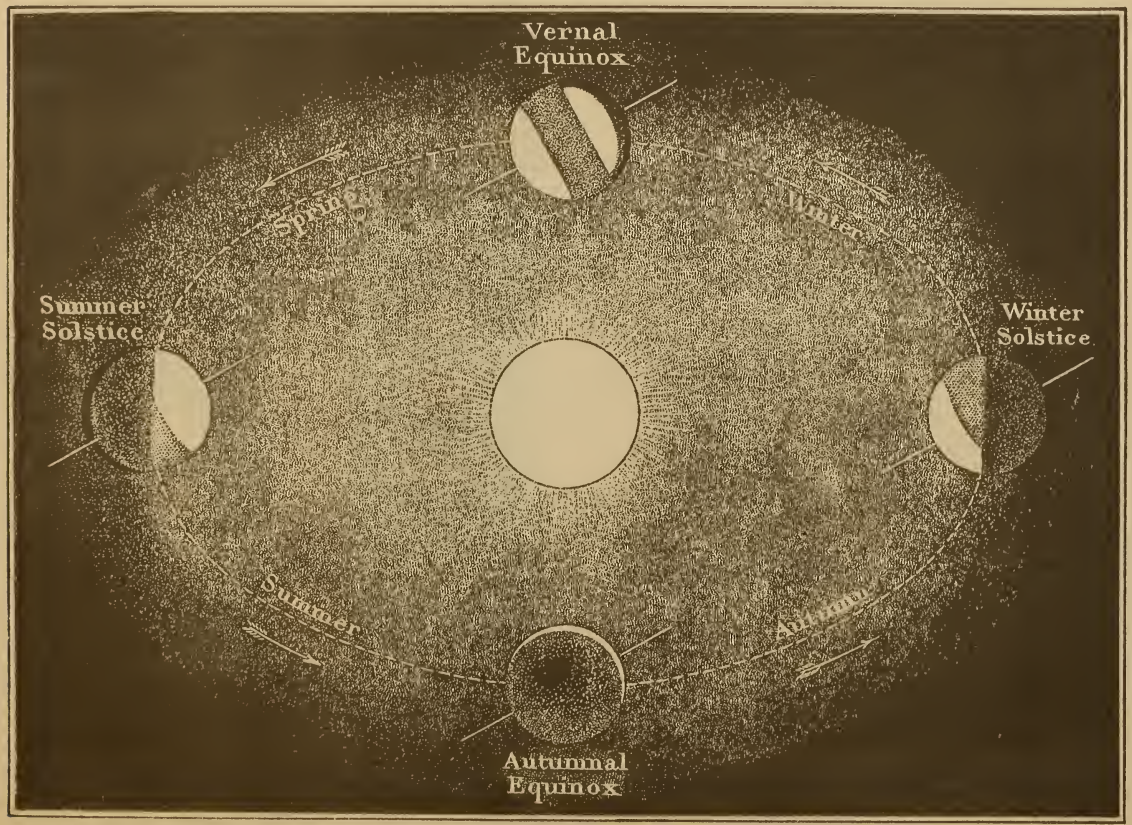
Q. What does this indicate?

A. The length of his day.

Q. Is he always uniform in his appearance?

A. He is not; he presents different phases like the moon; sometimes a crescent form, then gibbons; at other times a full face. See Figs. 11 and 12.

PLATE V.



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ORBIT OF MERCURY.

Let us speak first of its form. Mercury, in the course of one of its oscillations, presents phases entirely analogous to those of our Moon. It is at first a luminous disc, nearly circular, which by degrees is reduced on the side toward the east, until not more than a half-circle is visible at the period of its greatest apparent distance from the Sun; the crescent from henceforward characterizes it more and more, until it is only visible as a fine luminous thread. We give some of these phases. The progressive increase of its apparent dimensions is also shown in exact proportion. The same appearances are observed, but in inverse order, when Mercury is observed during the period in which he is a morning star.

Fig. 11.
Phases of Mercury when Seen After Sunset.

Fig. 12.
Phases of Mercury, when Seen Before Sunrise.

LESSON XV.

Analysis. — Transit — Primaries Making Transits — When Occur — Condition of Earth and Planet when it Occurs — Ecliptic — Nodes — Months in which Transits of Mercury Occur — Why? — Called What? — First Transit — Time of Others.

Transits.

Q. What is a transit?

A. The passage of a planet between the Earth and the Sun and apparently over his disc.

Q. Which of the primary planets have been known to pass over the Sun's disc.

A. Mercury and Venus.

Q. When can a transit never occur?

A. When the interior planet is in or very near the Ecliptic.

Q. When a transit takes place, what must be the condition of the Earth and the planet?

A. They must be on the same side of the Ecliptic and the Earth, on the same line of its nodes.

Q. What is the Ecliptic?

A. The Ecliptic is the plane of the Earth's orbit; or the great circle the Sun appears to describe annually among the stars.

Q. What are nodes?

A. The points at which a planet's orbit crosses the plane of the Ecliptic.

Q. When do all transits of Mercury take place?

A. In the months of May and November.

Q. Why?

A. Because the nodes of Mercury are on each side of the Ecliptic, and passed by the Earth in these months.

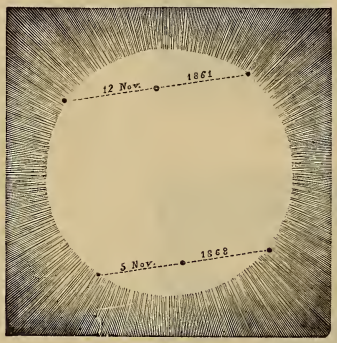


Fig. 13.
Transits of Mercury over the Sun, 1° the 12th November, 1861, 2° the 5th November, 1868.

Q. What are these months called?

A. They are called node months.

NOTE.—The Earth passes the ascending node of Mercury in November, and the descending node in May. The former of which is in the 16th degree of Taurus, and the latter in the 16th degree of Scorpio.

Q. When did the first transit of Mercury take place?

A. The first ever observed took place November 6, 1631.

Q. How many more have transpired since?

A. Thirty-two.

Q. When did the last transit occur?

A. November 4, 1868.

Q. How many will take place in this century?

A. Four—In May 6, 1878; November 7, 1881; May 9, 1891, and in November 10, 1894.

LESSON XVI.

ANALYSIS. — Mercury — Density — Heat — Solar Light — Velocity — Why so Great? — Conjunctions — Names — Distances from Earth in Different Conjunctions — In what Months Most Favorably Seen.

DENSITY AND HEAT OF MERCURY.

Q. What is the density of this planet?

A. About that of lead.

Q. What is the intensity of his heat?

A. It is supposed to be so great that water would be rapidly distilled into vapor, and that it would dissipate every volatile compound.

Q. What is its solar light, compared with that of the Earth?

A. It is seven times greater than that of the Earth.

Q. What is said of the velocity of this planet?

A. It is said to be the swiftest moving planet yet discovered.

Q. Why does he move swifter than any other planet?

A. Because being nearer the Sun than any other planet, the electrical power of the Sun, in attraction and repulsion, is far greater; therefore, he must of necessity move swifter, and the central force and circular motion must be equal to retain the planet in its orbit.

CONJUNCTIONS OF MERCURY.

Q. How many conjunctions has Mercury?

A. Two.

Q. What are they called?

A. Superior and Inferior.

Q. When and why is he said to be in his inferior conjunction?

A. When he is between the Earth and Sun, and because he is then in range with them.

Q. When and why is he in his superior conjunction?

A. When beyond the Sun, and in range with it and the Earth.

Fig. 14.
Equatorial Band of Mercury (Schroeter.)

Q. How far is Mercury from the Earth?

A. When in his inferior conjunction it is fifty-eight million miles.

Q. How far when in his superior conjunction?

A. One hundred and thirty-two million miles.

Q. What months are most favorable for observing this planet?

A. In the months of March or April, and in August or September, when its greatest elongation happens.

Q. Why is it not easily seen in winter?

A. On account of its low altitude above the horizon at sunrise and sunset.

Q. Why can it not be seen in summer?

A. The long twilight prevents our seeing any small object in the heavens.

The great proximity of Mercury to the solar rays renders the observation of the planet somewhat difficult; very little, therefore, is known of its surface. One diligent observer, Schroeter, at the end of the last century, was able, however, to observe some dark bands on its disc (fig. 14), which he considered as an equatorial zone; it was from the direction of these bands that he deduced the inclination of the axis of rotation.

Besides this, during the crescent phases, many observers (Schroeter, Beer and Madler) have seen indentations which make the line of separation of light and shade appear jagged; they also observed that the southern horn of the crescent was truncated (fig. 15). These markings were not always visible, but disappeared, to show themselves anew at intervals, the periodicity of which has enabled us to determine the period of rotation of Mercury. They evidently indicate the existence of high mountains, which intercept the light of the Sun, and of valleys plunged in shade, which lie near the parts of the surface of the planet then illuminated.

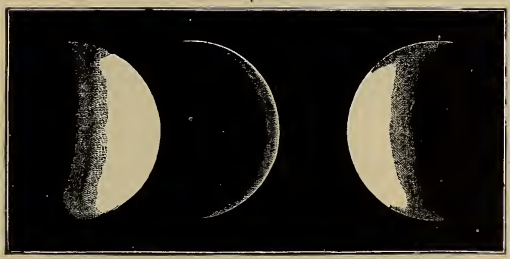


Fig 15.
Crescent of Mercury, showing irregularities on the terminator and the truncation of the Southern Horn. (Schroeter.)

Schroeter, when examining Mercury during its transit over the Sun on the 7th of May, 1799, saw, or believed that he saw, on the black disc of the planet a luminous point. It has been concluded from this observation, which has not, however, been confirmed, that there exist on the surface of Mercury active volcanoes. This would be another analogy between the physical constitution of this planet and that of the Earth.

LESSON XVII.

ANALYSIS. — Venus — Situation — Distance from Sun — Time of Revolution — Indication — Inclination of Orbit with Ecliptic — Time of Revolution on Axis — Indication — Rate of Motion — Inclination of Axis with Plane of Orbit — How Distinguished.

Q. What is the second planet?

A. Venus.

Q. Where is it situated?

A. Between the orbits of Mercury and the Earth.

Although Venus is one of the nearest planets to the Earth, astronomers have experienced great difficulty in measuring its apparent diameter in a precise manner. This is owing to the astonishing brilliancy of the light of Venus, and to the irradiation which is produced in its image in our instruments.

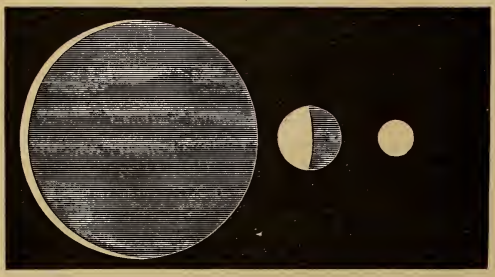


FIG. 16.
Apparent dimensions of Venus at its extreme and mean distance from the Earth.

Q. How far is it from the Sun?

A. Sixty-eight million miles.

Q. How long does it take Venus to make a revolution around the Sun?

A. Two hundred and twenty-five days.

FIG. 17.
Comparative dimensions of Venus and the Earth.

Q. What does this indicate?

A. The length of its year.

Q. What angle does the inclination of her orbit make with the Ecliptic?

A. Three degrees, twenty-three minutes and thirty-three seconds.

Q. How long does it take Venus to turn on its axis?

A. Twenty-three hours and twenty minutes.

Q. What does this determine?

A. The length of her day.

Q. What is the rate of motion in her revolution around the Sun?

A. Seventy-seven thousand miles an hour.

Q. What is the inclination of her axis to the plane of her orbit?

A. Ninety degrees.

Q. For what is Venus distinguished?

A. She is the most brilliant planet of all the orbs except the Sun and Moon.

LESSON XVIII.

ANALYSIS. — Satellite — Venus and Mercury Satellites of the Sun — Evidence — How Discovered — What Names — Diameter — Appearance — Similarity to Moon — Conjunctions — Appearance in Each.

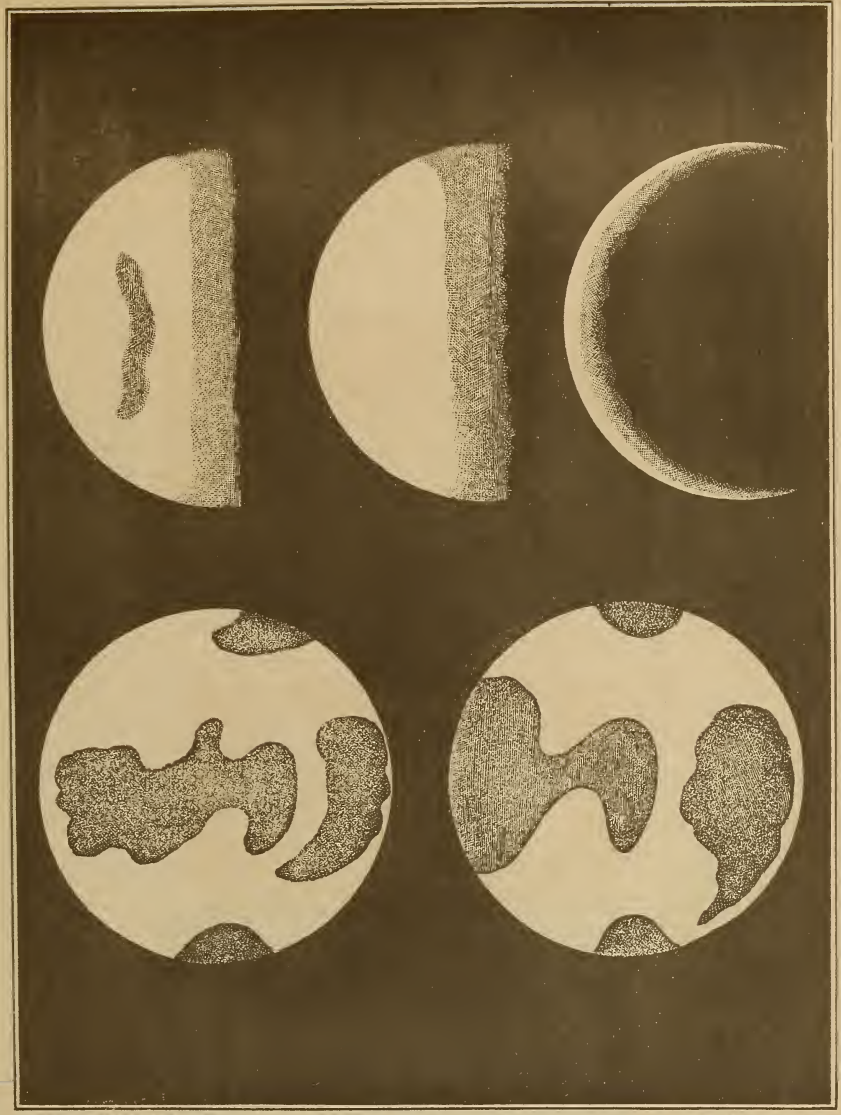
MERCURY AND VENUS SATELLITES OF THE SUN.

Q. What is a Satellite?

A. An attendant body of a primary planet.

Q. What evidences have we that Mercury and Venus are satellites of the Sun?

PLATE VI.



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FORM AND SURFACE MARKINGS OF VENUS.

A. Their close proximity to the Sun, and the uniformity of their movements and appearance.

Q. How can we now easily discover this planet Venus?

A. Because it is the largest and brightest of the stars.

Evening and Morning Star.

Q. By what name is Venus familiarly known?

A. Evening and Morning Star.

Q. Why?

A. Because for some months of the year she is found brilliantly shining in the west just after sunset, as the "Evening Star." She then gradually approaches the Sun, and for a time disappears, but soon reappears in the east in all her splendor, just before the rising Sun, as the "Morning Star."

Q. What is the diameter of Venus?

A. Seven thousand eight hundred miles.

Q. What is her appearance when seen through a telescope at different times?

A. All the different phases are manifest which we behold in the moon.

Q. Is Venus an interior or exterior planet?

A. Interior.

Q. Why?

A. Because she revolves within the orbit of the Earth, or between the Earth and the Sun.

Q. How many conjunctions have Venus?

A. Two — superior and inferior.

Q. When in superior conjunction?

A. When situated beyond the Sun and in range with it and the Earth.

Q. When is she in her inferior conjunction?

A. When between the Earth and the Sun, and in range with it.

Q. What is the appearance of the planet when in superior conjunction?

A. It is then full like our full moon.

LESSON XIX.

Analysis. — Venus — Different Changes — Diameter — Difference in Size — Transit — Time When — Benefit Derived — Appearance in Transit — Time of Transits — Time of Last One — Occur When — Time of Last — When Next — Peculiarity of Twentieth Century — How far Recede from Sun.

Changes of Venus.

Q. What change then occurs?

A. It gradually diminishes until, at the time of its great elongation, only half of the disc is seen, then the planet continues to wane, until near its inferior conjunction it assumes the form of a slender crescent.

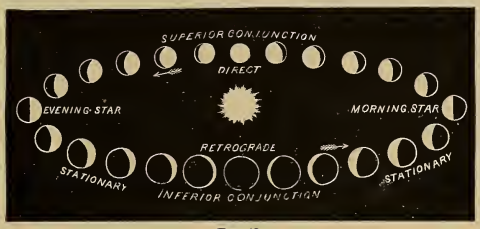

Fig. 18.
The Variations of Venus.

Q. Why is the apparent diameter least when the planet is full?

A. Because it is then farthest from the Earth?

Q. When is it greater than at any other time?

A. It is always greater when near an inferior conjunction than at any other time, except when it is seen during her transit.

Q. What is meant by her transit?

A. Her passage across the disc of the Sun.

Q. Why does it not occur at every inferior conjunction?

A. Because one-half of this planet's orbit is three and one-half degrees below the plane of the Earth's orbit, and the other half as many degrees above it.

Q. What benefits have been derived from investigating the transits of Venus?

A. Owing to the minute investigations of them, the distance of the Sun and the dimensions of the planetary system have been more cleary determined.

Q. How long do some of these transits last?

A. Nearly seven hours.

Q. What is her appearance in a transit?

A. That of a dark spot.

Q. When did her last transit take place?

A. In the year 1769.

Q. Are these transits of frequent occurrence?

A. They are very rare, taking place at intervals of about eight and one hundred and thirteen years.

Q. When will the next transit transpire?

A. December 8th, 1874.

Q. At what time will the next occur?

A. December 6th, 1882.

Q. What peculiar fact respecting the transit of Venus during the twentieth century?

A. There will be no transit in that century.

Q. When will there be another transit of Venus?

A. June 7th, 2004.

Q. How far does Venus recede from the Sun when in its extreme elongation?

A. Forty-seven degrees.

LESSON XX.

ANALYSIS. — Mountains of Venus — Height — Schroeter's Statement — Volume — Light Compared to that of the Earth — Distance from the Earth — In Different Conjunctions — Circumference of Orbit — Phases — Evidence of What — How Change her Appearance.

MOUNTAINS OF VENUS.

Q. What is known of the Mountains of Venus?

A. Schroeter states that the Mountains of Venus are twenty-seven miles high, or five times the height of the loftiest peak on the Earth.

The solid ground of Venus is uneven, like that of Mercury and of the Earth; it is covered with high mountains. But is it certain that these asperities attain such a considerable height as is stated? Do mountains exist on Venus to the vertical elevation of twenty-seven miles; that is to say, five times higher than the most elevated peak in Thibet, ten times the colossal Mont Blanc? This is a delicate question which subsequent measurement may perhaps settle. But if the first results were confirmed, we could scarcely help thinking of the strange aspect the mountainous regions of Venus would offer; the sublime peaks of our Alpine regions would be but mere mole-hills in comparison. If we refer to the drawings of Schroeter (see plate V.), which represents Venus in three of its phases, we shall notice that the luminous part of the disc is far from terminating abruptly along the line of shade. Its light, on the contrary, diminishes gradually; and this diminution may be entirely explained by the twilight on the planet.

Q. What is said of its volume?

PLATE VII.

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THE EARTH SUSPENDED IN SPACE.

A. It is a little less than that of the Earth.

Q. How does the quantity of light compare with that of the Earth?

A. It is about twice as great.

Q. How far is Venus from the Earth when in her inferior conjunction?

A. Twenty-seven million miles.

Q. How far is her superior conjunction?

A. One hundred and sixty-three million miles.

Q. What is the circumference of her orbit?

A. Five hundred and thirty-three million eight hundred thousand miles.

Q. What length of time intervenes between one conjunction and another?

A. Five hundred and eighty-four days.

Q. During this time what may be observed of her?

A. That she passes through all the motions and phases of an Evening and Morning Star.

Q. What does this prove?

A. That the Sun is in the center of the Solar System, and that the Earth, on which we live, is revolving around it in an orbit more distant than Venus.

Q. Were the enlightened hemisphere of Venus turned toward the Earth, when in that point of the orbit nearest to us, how would she appear?

A. Like a brilliant moon, twenty-five times larger than she now appears to the naked eye.

Q. Why does she not appear so to us?

A. Because at that time her light side is turned toward the Sun, and her dark side toward the Earth.

LESSON XXI.

ANALYSIS. — The Earth — Situation — Form — Spherical — Evidence — Not Perfect — Proved — Difference of Diameter — Position Important.

THE EARTH.

Q. What is the Earth?

A. An opaque body; the third planet in the order of distance from the Sun?

Q. What is its form?

A. That of an oblate spheroid, approaching nearly to the form of a globe.

Q. What is an oblate spheroid?

A. A sphere flattened at two points opposite each other, called the poles.

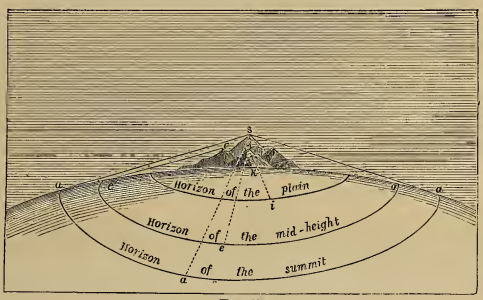


FIG. 19.
A Mountain figured on a Plain.

In explanation of the following figures, let us dwell a short time on their different points.

It is well known that the horizon of a plain presents the form of a circle surrounding the observer. If the latter moves, the circle moves also, but its form remains the same, and is modified only when mountains or other obstacles of some elevation limit the view. Out at sea, the circular form of the horizon is still more decided (fig. 19),

and changes only near the coasts, the outline of which breaks the regularity.

Here, then, we obtain the first notion of the rotundity of the earth, since a sphere is the only body which is always presented to us under the form of a circle, from whatever exterior point of view it is examined. Moreover, it cannot be said that the horizon is formed by the limit of distinct vision, and that it is this which causes the appearance of a circular boundary, because the horizon is enlarged when we mount vertically above the surface of the plain. The preceding drawing, in which a mountain is figured in the middle of a plain, whose uniform curvature is that of a sphere, will prove our assertion. From the foot of the mountain the spectator will have but a very limited horizon. Let him ascend half-way, his visual radius extends, is inclined below the horizon, and reveals a more extended circular area. At the summit of the mountain the horizon increases, and if the atmosphere be pure, the spectator will see numerous objects appear; where, from the lower stations, the sky alone was visible.

Fig. 20

This extension of the horizon would be inexplicable if the Earth had the form of an extensive plain. The curvature of the surface of the sea manifests itself in a still more striking manner. Suppose yourself on the coast, at the summit of a high tower, hill or steep, rocky shore; a vessel appears on the horizon, you see only the tops of the masts — the highest sails; the lowest sails and the hull are invisible; as the vessel approaches, its lower part comes into view above the horizon, and soon it appears entire. (Fig. 20.)

The fact of the successive appearances on the surface of the sea, or the different parts of an object, beginning by the highest parts of it, is manifested in the same manner to the sailors who, from the ship, observe the land. The explanation is rendered clear in the following sketch, where the course of a vessel, seen in profile, is figured on the convex surface of the sea. (See fig. 21.)

As the curvature of the ocean is the same in every direction, it follows that the earth has really the form of a sphere, or at least differs from it but little.

Fig. 21.
A Vessel figured on the Convex of the Sea.

Q. How do we know the Earth is spherical?

A. By the sailing of a ship around it.

Q. Who first sailed around the Earth?

A. A Portuguese by the name of Ferdinand Magellan.

Q. Who next made the voyage?

A. Sir Francis Drake.

Q. In what year and from whence did he sail?

A. He sailed from Plymouth, December 13, 1577, with five small vessels, and arrived at the same place from whence he started September 26, 1580.

Q. Since that time has the Earth been circumnavigated?

A. By many others; among them Cavendish and Cordes.

Q. In what direction did they sail?

A. In a westerly direction.

Q. What other proof have we that the Earth is nearly round?

A. The shadow of the Earth in the eclipse of the Moon indicates a globular figure.

Q. Is the Earth a perfect sphere?

A. It is not.

Q. How is this known?

A. By actual measurement. The degrees from the equator to the poles are not uniformly the same; but increase in length with the latitude, as we go from the equator to the poles, thus showing the Earth is not a true sphere or globe.

Q. What is the longest or equatorial diameter?

A. Seven thousand nine hundred and twenty-four miles.

Q. What is the polar diameter?

A. Seven thousand eight hundred and ninety-eight miles.

Q. What is the mean diameter?

A. Seven thousand nine hundred and twelve miles, and their difference twenty-six miles.

NOTE. — The Earth, considered as a planet, holds a very important and conspicuous position in the solar system. It has pleased an infinitely wise Creator to assign its positions among the heavenly bodies, where nearly all of them are visible to the naked eye.

LESSON XXII.

ANALYSIS. — Revolution of the Earth — Time — Indication — Changes of Seasons — Axis — Position — Time of Revolution on Axis — Production — Cause of its Revolution on its Axis — Explanation — Illustration — Law Equally Essential in all Planets — Problem Solved — Distance from Sun — Circumference of Orbit — Rate of Motion — Inclination of Axis.

REVOLUTION OF THE EARTH.

Q. How long does it take the Earth to revolve around the Sun?

A. It moves around the Sun from west to east in 365 days, 5 hours, 48 minutes and 48 seconds.

Q. What is this called?

A. Her year, or annual motion.

Q. What does this annual motion produce?

A. The changes of seasons.

Q. What is the axis of the Earth?

A. An imaginary line passing through the center of the Earth and terminating at the poles.

Q. What is the position of its axis?

A. It is always parallel to itself, pointing in the same direction in the heavens.

Q. How often does the Earth turn on its axis?

A. Once in every 24 hours.

Q. What is this called?

A. Her diurnal motion, or her day.

Q. What does this revolution produce?

A. The succession of day and night.

In view of the fact, admitted by all, that God created the planets, and sent them rolling in their respective orbits, we come to the conclusion that He has constituted a certain law by which they are continued in motion; hence, we present the hypothesis that they are continued in their revolutions by the electrical law of Attraction and Repulsion.

We call attention now to the following explanation of this law, and humbly ask of the Scientific World to present another more feasible one, and in which the controlling power of the Sun can be illustrated by attraction and repulsion.

Q. What law continues the revolution of the Earth on its axis?

A. The immutable law of *Electricity*, manifest in *attraction and repulsion.*

Q. How is that law explained?

A. *Two positives* repel each other, and a *positive* and a *negative* attract each other.

Q. How is this law illustrated in the continued revolution of the Earth?

A. That part of the Earth which has been longest in the rays of the Sun having become positive, by the electrical influence of the Sun, is repelled. The opposite portion of the Earth, lying in the dark, and thus becoming deeply negative, is attracted by the positive Sun; hence, the revolution of the Earth is continued.

Q. Is this law simply applicable to the revolution of the Earth on its axis?

A. Certainly not. It is equally essential to the revolution of every planet in the Solar System.

Q. In applying this law to the revolution of the planets, what problem is solved which hitherto has remained a mystery?

A. The cause of attraction and repulsion.

Q. How far is the Earth from the Sun?

A. When the Earth is in aphelion, the distance is ninety-three million miles; when in perihelion, it is ninety million miles, the mean distance being ninety-one and one-half million miles.

Q. What is the circumference of the Earth's orbit?

A. It is six hundred million miles.

Q. What is the rate of the Earth's motion?

A. It is sixty-eight thousand miles an hour.

Q. What is the inclination of the axis of the Earth?

A. It is twenty-three and a half degrees from a perpendicular to the plane of the Earth's orbit.

LESSON XXIII.

ANALYSIS. — Time — How Reckoned — Uniformity — Advantage Derived — Remarks — Plane of Ecliptic Illustrated — Kepler's Law — Location of Sun in Earth's Orbit — Shape of Orbit.

How Time is Reckoned.

Q. Is the rotation of the Earth on its axis always uniform and invariable?

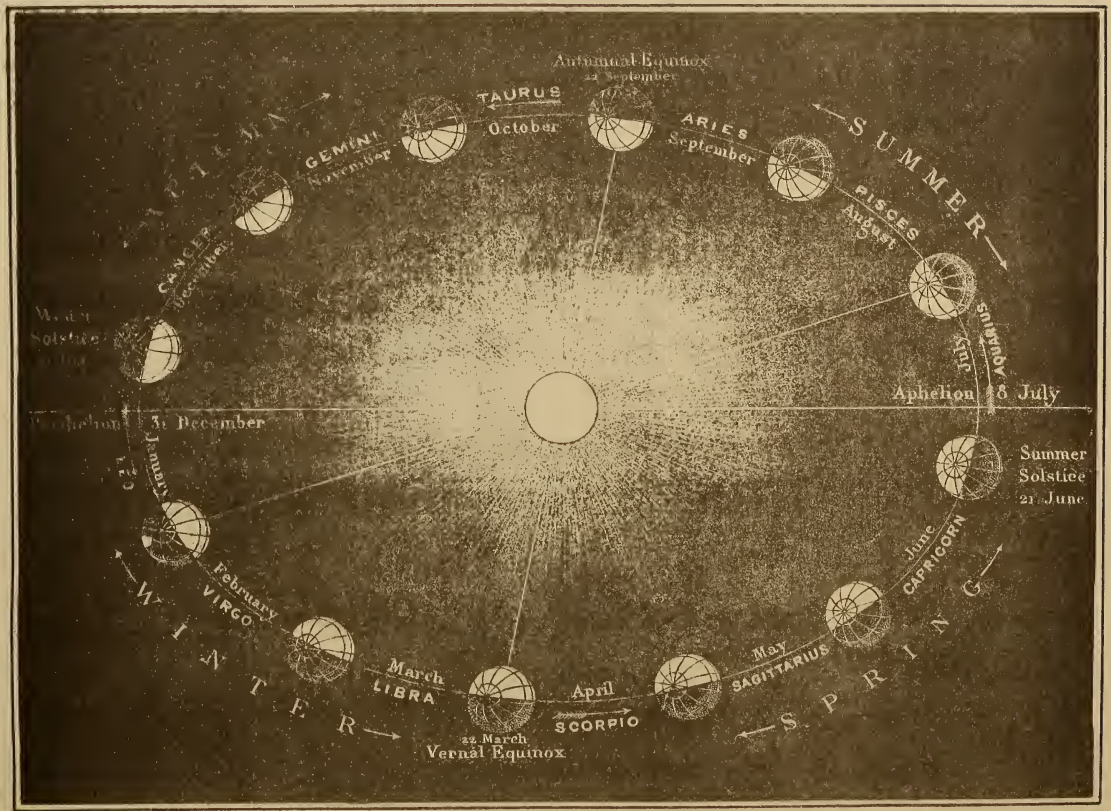
A. Its revolution is invariably the same, once in twenty-four hours.

Q. What advantage is derived from this regularity of the Earth's motion?

A. We obtain by this the only true principle of reckoning time in hours, days, etc.

Remark.— 1st. While all the other periodical motions of the heavenly bodies are subject to change, this has remained the uniform standard, having undergone not the slightest appreciable change from the date of the earliest observation.

PLATE VIII.



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ORBIT OF THE EARTH.

AND THE SEASONS.

2d. The different periods of time in common use all date from this. Weeks, months and years are recorded by days and fractions of a day; while hours, minutes and seconds are divisions and subdivisions of the day.

Q. How may we illustrate the plane of the Ecliptic?

A. By filling a bowl with water, the rim will represent the orbit, the surface of the water even with the rim of the bowl, the plane of the Ecliptic, and the bowl would represent one-half of the concave sky.

Q. What law of Kepler respecting the planets, by which the primary and secondary are regulated, and to which law there is no exception known?

A. That the square of the periodic times of the planets' revolution is as the cubes of their distances.

Q. How far is the Sun one side of the center of the orbit in which the Earth moves around it?

A. It is about three million miles.

Q. What is the shape of the Earth's orbit?

A. It is that of an ellipse.

LESSON XXIV.

ANALYSIS. — Causes of their Change — How far is the Axis of Rotation Inclined to Plane of Ecliptic — Time of Year — Equal Day and Night — Why Then — Why Day — Why Night — The Result of the Revolution of the Earth on its Axis — Points Called — Way of the Revolution.

THE SEASONS.

Q. What causes the change of the seasons?

A. First, the fact that the Sun illuminates but one-half of the Earth at a time; secondly, that the axis on which the Earth revolves is inclined to the plane of the Ecliptic; thirdly, that its position at any one point in the Earth's orbit is invariably parallel to its position at every other point.

Q. How far is the axis of rotation inclined to the plane of the Ecliptic?

A. About sixty-seven and a half degrees.

Q. At what time of the year do we have equal day and night?

A. On the 21st of March and on the 23d of September.

Q. Why do we have equal day and night at that time?

A. The Sun at those points strikes us vertically at the equator and shines from pole to pole.

Q. What is the side of the Earth toward the Sun called?

A. It is called Day.

Q. What is the side turned from the Sun called?

A. It is called Night.

Q. What is the result of the revolution of the Earth on its axis?

A. Where it was day it becomes night, and where it was night it becomes day, and the day and night are equal.

Q. What are those points called?

A. Equinoctial points.

Q. Which way does the Earth move around the Sun?

A. From west to east.

N. B. — The teacher will explain this on the Diagram in the first part of the Atlas.

LESSON XXV.

ANALYSIS. — Difference of Time in the Days and Nights Explained — Summer Solstice — Why so Called — Distance the Sun Shines Beyond the North Pole — Situation of South Pole — Movements of the Sun Further Explained.

The following instruction should be illustrated by the teacher on the Diagram:

Q. Why do the days grow longer and the nights shorter from the 20th of March until the 21st of June?

A. Owing to the inclination of the Earth's axis as the Earth moves along in her orbit from her place in March, more and more of the northern hemisphere is coming into the light of the Sun; and the Sun shines farther and farther beyond the North Pole until the 21st of June, hence the Earth turning on its axis; in the meantime, the days continue to increase till then, and nights grow shorter in the same proportion.

Q. Why is the 21st of June the longest day in the year?

A. The most of the northern hemisphere is enlightened that can be at any one time.

Q. What is this point called?

A. The summer solstice.

Q. Why is it so called?

A. The Sun then has its greatest northern declination, or is at its greatest distance north of the equinoctial line, or the equator.

Q. How far does the Sun then shine beyond the North Pole?

A. It shines twenty-three and a half degrees.

Q. What is the situation of the South Pole at this time?

A. It is entirely in the dark.

Q. What takes place when the Sun reaches the summer solstice?

A. It then ceases to decline from the equinoctial, and begins to return toward it.

Q. How is this accomplished?

A. By the Earth moving along in her orbit, the North Polar circle advances farther and farther into the dark, and the South Polar circle in a corresponding manner extends into the light until the 22d of September, when the Sun again strikes vertically at the equator and shines from pole to pole, causing once more equal day and night.

Q. Why do the days grow shorter and the nights longer from the 22d of September till the 21st of December?

A. The axis of the Earth being inclined always in the same direction, as the Earth moves along from west to east in her orbit, the North Polar circle recedes farther into the dark, and the South Polar circle advances more and more into the light, so that less of the northern hemisphere is enlightened by the Sun, and more of the southern until the 21st of December the Sun has reached its greatest southern declination, or is at its greatest distance south of the equinoctial, when the winter solstice is reached, and when the Ecliptic and the Equator are at their greatest distance from each other.

LESSON XXVI.

ANALYSIS. — Length of the Days and Nights Considered — Number of Seasons — What Called — ZODIACAL LIGHT — Time of Appearance — In what Part of the Heavens — Form of the Light — Compared with Milky Way — Not Seen at all Seasons — When Only — In what Months — Favorable Nights — Zodiac — What is it — Description of Belt — How Occupied — Location of Ecliptic — Term "Constellation" — By Whom Used — Why Called Zodiac — What Use is made of the Signs of the Zodiac — Names — Correspondents of these — The Earth in Capricorn — Where then is the Sun Vertical?

Q. What may be said of the days and nights at this time?

A. The days are the shortest and the nights the longest of any time during the year.

Q. As the Earth continues on in her course, what effect is produced?

A. The days grow longer and the nights shorter until they become equal again, on the 21st of March.

Q. How many seasons have we?

A. Four.

Q. What are they called?

A. Spring, Summer, Autumn and Winter.

THE ZODIACAL LIGHT.

In the evenings, about the time of the vernal Equinox, — in March and April, — when in our climate the twilight is of short duration, if we examine the horizon toward the west a little after sunset, we may perceive a faint light that rises in the form of a cone among the starry constellations. This is what astronomers call the *Zodiacal Light.*

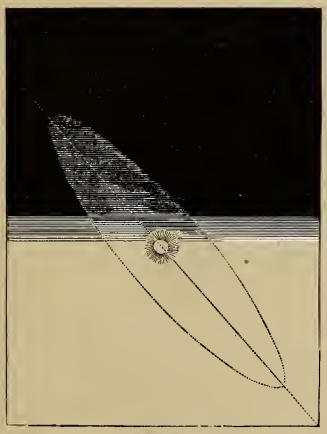

FIG. 22.
Direction of the Axis of the Zodiacal Light.

Let us see now if it is possible to account for the nature of the Zodiacal Light, which evidently is not a purely meteorological phenomenon, since its participation in the diurnal movement, its visibility in regions of the Earth very distant one from the other, and, lastly, its nearly invariable inclination along the Ecliptic, indicate sufficiently that the cause which produces such appearances lies outside our atmosphere, in the celestial spaces.

Among the explanations that have been given, the most probable one is that which likens the Zodiacal Light to a flattened nebulous ring surrounding the Sun at some distance. It is to be remarked, that the direction of the axis of the cone, or of the pyramid, prolonged below the horizon, always passes through the Sun. (See Fig. 22.)

It was believed at first that this direction precisely coincided with the solar equator; but it seems more certain that it coincides with the plane of the Earth's orbit, or the Ecliptic.

Another hypothesis, also connected with the first is that the *Zodiacal Light* is formed from myriads of solid particles analogous to the aerolites, possessing a general movement but traveling separately around the focus of our solar world.

The light of the ring would be thus produced by the accumulation of this multitude of brilliant points reflecting toward us the light borrowed by each of them from the Sun. This explanation accounts for the variation of the intensity of the Zodiacal Light at different epochs; it would suffice to admit that the condensation of the particles or the density of the ring is not the same throughout its extent, and its movement of its circulation round the Sun presents, successively, different parts to the Earth. In this case, it becomes a question whether this lenticular ring of matter is distinct from the systems of meteors, of which we shall hereafter speak, and the existence of which seems at length established.

Q. In what season of the year does the light make its appearance?

A. In March and April; in the evenings, about the time of the Vernal Equinox.

Q. In what part of the heavens does it appear?

A. It is seen in the west, near the place where the Sun sets.

Q. What is its form and appearance?

A. It extends upward in the form of a cone, and is brighter in appearance than the Milky Way.

Q. Why is it not seen at all seasons of the year?

A. It is only seen when our twilight is of short duration; when it increases the Zodiacal Light disappears.

Q. Is it not seen at any other time of the day, or of the year?

A. It may be seen about the time of the Autumnal Equinox, in the months of September and October, in the morning, when the dawn has an equally short duration.

Q. When is it most favorable to take a view of it?

A. When the night is clear and the night is moonless.

Zodiac.

Q. What is the Zodiac?

A. It is an imaginary belt, 16 degrees in width surrounding the heavens from west to east.

Q. What does this Belt show?

A. The width of space occupied by the planets of our solar system in revolving around the Sun.

Q. What part of this space is occupied by the Ecliptic?

A. The center; hence eight degrees lie on one side and eight on the other of the orbit.

Q. Who first applied the term "constellation" to that portion of the heavens embraced in the Zodiac?

A. The Chaldeans or Egyptians.

Q. Why was it called Zodiac?

A. From the Greek word "Zoon," which means an animal.

Q. What did the Chaldeans imagine?

A. That many animals and objects were represented in the heavens.

Q. How many are the signs of the Zodiac?

A. There are twelve. (See plate of the Seasons.)

Q. To what purpose did the signs of the Zodiac serve the ancients?

A. That of Calendar, enabling them to tell when to plant and sow their grain.

Q. What names were given to the constellations forming the Zodiac?

A. Aries, Taurus, Gemini, Cancer, Leo, Virgo, Lebra, Scorpio, Sagittarius, Capricornus, Aquarius, and Pices. (Refer to plate above.)

Q. To what do these constellations correspond? (See plate of the Seasons.)

A. To the twelve months of the year, beginning at September, letting it be represented by Aries, October by Taurus, and so on.

Q. When the Earth is in that constellation called Capricorn, where is the Sun then vertical?

A. To the constellation in the heavens directly opposite at Cancer.

LESSON XXVII.

ANALYSIS.— What Does This Show — Why Warmer on the 21st of June — Sun Further Away — Difference in Diameter — Difference of Time in Equinoctial Points — Nearest the Sun Perihelion — Fartherest Aphelion — Motion Faster at Which — Density — Variation of Equinoctial Points — Difference of Diameter — Discovery — Weight at the Poles and the Equator — Cause of This.

Q. What does this show?

A. That when it is Summer with us in the Northern Hemisphere, that is in June, in the constellation Capricorn, and the Earth passes in its orbit to the direct opposite point in the constellation Cancer, which is December, the inhabitants will have then the same season of the year, south of the Equator, that we had in June north of the Equator, and so at every opposite point of the Earth's orbit.

Q. Why is it warmer with us, north of the Equator, on the 21st of June, when we are three millions of miles further from the Sun than on the 21st of December?

A. The Sun rises to a much higher altitude above the horizon in Summer than in Winter, hence, its rays fall more directly and less obliquely upon the surface of the Earth.

Q. What is the difference of the length between the longer and the shorter diameter of the Earth's orbit?

A. It is three millions two hundred and thirty-six thousand miles.

Q. How is this ascertained?

A. From the variation of the apparent diameter of the Sun.

Q. What is the difference of time between the Equinoctial points?

A. There are between seven and eight days more between the 21st of March to the 23d of September than from the 23d of September onward to the 21st of March.

Q. What is that point called when the Earth is nearest the Sun?

A. It is called Perihelion distance?

Q. What is that point of its greatest distance called?

A. It is called Aphelion.

Q. Does the Earth move faster at its Perihelion than its Aphelion distance?

A. It moves more than three thousand miles an hour faster.

Q. What is the density of the Earth?

A. About five times that of Water.

Q. What is known in regard to the varying of the Equinoctial points?

A. They are slowly receding or falling back westward on the Ecliptic.

Q. How is this caused?

A. The Earth, in passing around the Sun, reaches the Equinoctial points twenty-two minutes and twenty-three and a half seconds earlier each year, and in the course of twenty-five thousand eight hundred and sixty-eight years they will perform a retrograde motion quite around the heavens.

Q. What is the difference between the length of the Equatorial and the Polar diameters of the Earth?

A. The Equatorial diameter is about thirty-four miles the longer.

Q. What trifling circumstance led to this important discovery?

A. The difference of the number of the vibrations of a pendulum of the same length makes in different latitudes; also that a body or substance weighing 194 pounds at the Equator would weigh 195 pounds at the poles.

Q. What is the cause of a body weighing more at the Poles than at the Equator?

A. The motion of the Earth's surface is not so great as at the Equator, and it is nearer the center of the Earth, hence, the body would not have so great a tendency to fly off, and, being nearer the center of the Earth, is attracted toward it with more force.

LESSON XXVIII.

ANALYSIS. — The Moon — Form of Orbit — Perigee — Apogee — Mean Distance — Inclination of its Orbit to Plane of Ecliptic — Lunar Days in a Year — How much of Moon Seen — Illustrated — Evidence of any Life on the Moon — Result if there were — Any Seas, Lakes, Rivers — Any Winds or Tornadoes.

THE MOON.

Q. How many Satellites has the Earth?

A. The Earth has one Satellite, called the Moon.

Q. How far is it from the Earth?

A. It is two hundred and forty thousand miles.

Q. How long does it take this Satellite to revolve around the Earth?

A. It takes 27 days, 7 hours and 43 minutes and 11½ seconds from one fixed star to the same fixed star again.

Q. What is the form of its orbit?

A. It is Elliptical.

The Teacher in giving the instruction of the Moon should frequently refer to the Diagram in the front part of the Atlas.

PERIGEE AND APOGEE.

Q. What is the point nearest the Earth called?

A. It is called the Perigee.

Q. What is the point farthest from the Earth called?

A. It is called the Apogee.

Q. What is its mean distance from the Earth?

A. It is two hundred and thirty-eight thousand eight hundred miles.

Q. How much nearer to us in Perigee than in Apogee?

A. It is twenty-six thousand miles.

Q. What is the inclination of the Moon's orbit to the plane of the Ecliptic?

A. It is five degrees and eight minutes.

Q. What is the diameter of the Moon?

A. It is two thousand and one hundred and sixty miles.

Q. What is the difference between a lunar day and a month upon the earth?

A. There is no difference in time.

Q. Then how many lunar days make a year?

A. It takes thirteen days.

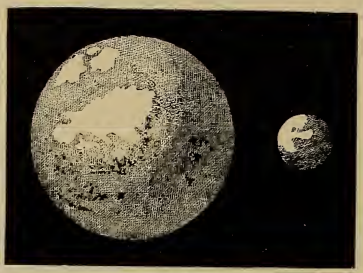

Fig. 23.
Comparative Dimensions of the Earth and Moon.

Q. How much of the Moon do we see?

A. Only one side is ever seen; that being turned toward us when seen.

Q. How may this be illustrated?

A. Let a person walk around an object, keeping his face toward it all the time, and he will beautifully illustrate the manner the Moon always turns her face toward and goes around the Earth.

Remark. — Here the teacher should turn the attention of the class to the diagram in the first part of the Atlas.

Q. Have we any evidence that there is animal or vegetable life on the Moon?

A. None whatever; no moving object has ever been seen on the disc of the Moon.

Q. Is there any evidence that there are seas, lakes, or rivers on the Moon?

A. If there were, the solar heat would develop a gaseous envelope, and thick clouds of vapor, which have never been discovered.

Q. Are there winds or tornadoes manifest over the surface of the Moon?

A. There being no water, of necessity there is an absence of winds, currents, or even air itself.

PLATE IX.

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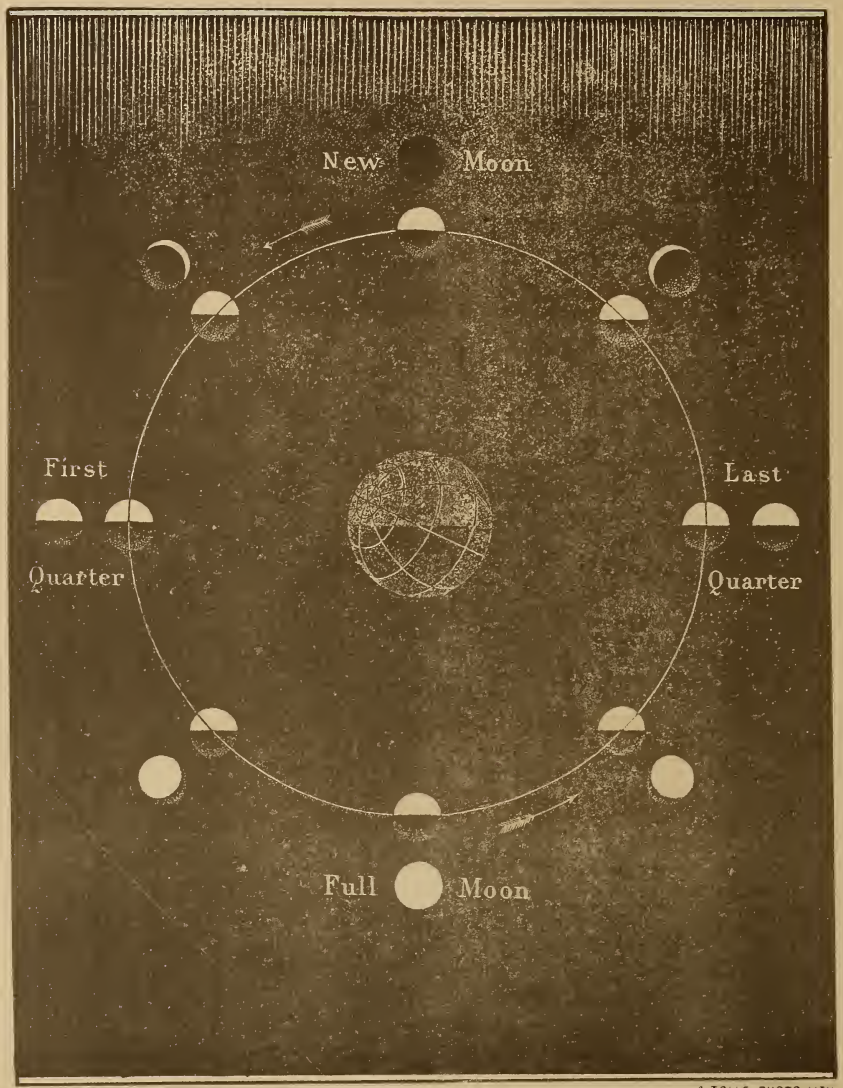
LUNAR LANDSCAPE.

PLATE X.



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ORBIT OF THE MOON.

EXPLANATION OF THE PHASES.

LESSON XXIX.

Analysis. — Phases of the Moon — Explanation of them — First Appearance where — At what time — Way of Revolution — Degrees in twenty-four hours — Her Changes Explained — Time of Full Moon — Position now in Respect to Sun — Why in Opposition.

Phases of the Moon.

Q. What is understood by the Phases of the Moon?

A. They are different illuminated aspects she presents in her revolution around the Earth.

Q. In her revolution, what is her first appearance?

A. She appears in the form of a beautiful crescent, with horns turned toward the east.

Q. In what part of the heavens and at what time does she appear in this form?

A. She may be seen in the west just after sunset.

Q. Which way does she revolve around the Earth?

A. From west to east.

Q. How many degrees eastward does she pass in twenty-four hours?

A. She passes thirteen degrees, ten minutes, and thirty-five seconds.

Q. What changes take place in her luminous appearance from evening to evening, as she continues her revolution?

A. As she departs further and further from the Sun, her enlightened surface comes more and more into view.

Q. How many degrees does she pass in reaching her first quarter?

A. She passes just ninety degrees.

Q. What is her appearance at this point?

A. Having finished just half of her course from the new to the full Moon, she presents just one-half of her enlightened hemisphere toward the Earth.

Q. What changes mark her appearance as she continues her course?

A. She constantly increases her luminous appearance, presenting a gibbous face to the Earth.

Fig. 24.
Rotation of a Sphere, supposed to be at rest.

We must recollect that it is the phases of the Moon which have demonstrated to us its revolution round the Earth. This movement, added to the fact that the Moon constantly presents the same hemisphere to the Earth, proves that it turns also on itself, in a period of time exactly equal to the length of its sidereal revolution, that is to say, in about twenty-seven days and a third.

In speaking of the movement of rotation of the Moon on its axis, it is right to anticipate an objection often made, proceeding from a false idea sometimes conceived of the rotatory movement of a movable body. "Since the Moon," it is said, "always presents the same face to us, it cannot turn on itself. If it turned on an axis or pivot, it ought to present us all its sides successively." Such is the objection simply put.

To solve this difficulty, let us examine into the

phenomena. What is a movement of rotation? How is it known that a body, a sphere for example, does rotate? and how is it known when an entire rotation has been completed? Evidently, when the sphere has presented successively one of its sides toward every point of the space which surrounds it. If we divide the entire rotation into four periods, the accompanying diagram will show how the sphere would be seen at the commencement of each of those periods, to an observer at rest.

Now, if the sphere, during the exact time that it takes to effect this rotation round its axis, executes a movement of revolution round the observer, whether the observer be at rest or not, it is none the less evident that the entire rotation would be effected, if the side, of which the point A forms the apparent center, is successively presented to all parts of space. Now, this is the case with the Moon, during a complete revolution in its orbit, as may be seen from the comparison of figures 24 and 25.

Q. What changes occur in one lunation of the Moon?

A. It passes from one Full Moon to another.

Q. How many times does it cross the orbit of the Earth in the course of one lunation?

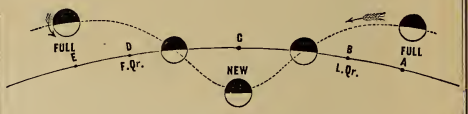

Fig. 25.

Actual Movement of Rotation of the Moon in the Interval of a Lunation.

A. It crosses it twice.

Q. Does it continue to indicate the same position at the end of its rotation as it did at the beginning?

A. Comparing the indication of the two Full Moons with respect to the location of the Earth, there is a continued variation during the entire rotation.

Q. Why is there a variation?

A. This must necessarily take place in order that the same side of the Moon be presented to us all times.

Q. What occurs when she has accomplished one-half of her circuit around the Earth?

A. She appears then as a Full Moon.

Q. What is now her position, with respect to the Sun?

A. She is in opposition.

Q. And why in opposition?

A. Because she is then on the opposite side of the Earth, with respect to the Sun, and is rising in the east just as the Sun is setting in the west.

PLATE XI.

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A. TOLLE, PHOTO-LITH.

THE FULL MOON.

(TELESCOPIC VIEW.)

LESSON XXX.

ANALYSIS. — Appearance in the First Half of her Orbit — Appearance in the Last Half — What Remarkable in her History — When Called New Moon — When Full Moon — Relation to the Earth — Satellite — Time of Revolutions — What Called — How Near the Earth — Revolutions in a Year — Synodic and Siderial Revolution.

The *Siderial* revolution of the Moon around the Earth is accomplished in about twenty-seven and a third days, but, owing to the revolution of the Earth in its own orbit around the Sun, it takes more than two days longer to complete its *Synodic* revolution and come into the same position as before, with respect to the Sun and Earth.

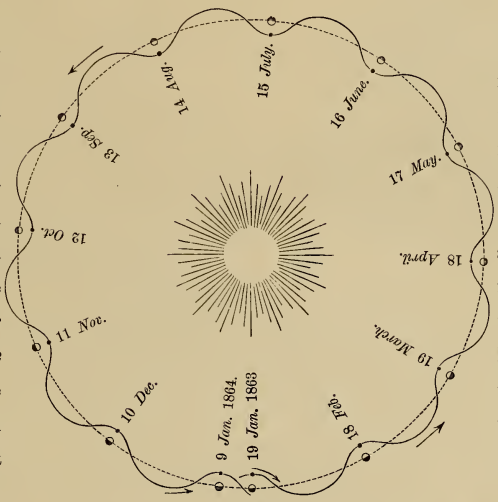


Fig. 26.
The curve described in a year, by the Moon round the Earth.

The wave-like motion of the Moon, by which it crosses the path of the Earth twice each month is produced by a combination of its own peculiar motions and the onward movement of the Earth. As the same side of the Moon is kept constantly toward us, it is evident that it must turn on its axis once each month.

Q. In passing over this half of her orbit how has her course appeared to us?

A. She has apparently passed over our heads in the upper hemisphere.

Q. What change takes place now in her aspect?

A. She continues to wane; rising later on each successive evening.

Q. During her progress through the east half of her orbit how does her course appear to us?

A. She seems to descend below the eastern horizon and pass through the lower hemisphere.

Q. In what form does she next present herself?

A. We next behold her in the morning a little west of the rising Sun, in the form of a crescent with its horns inverted, turned now toward the west.

Q. What now transpires which is remarkable in her history?

A. She rises and sets in conjunction with the Sun and for two or three days we lose sight of her altogether.

Q. By what different terms is she called in the first half of her revolution around the Earth?

A. When in conjunction, she is called *New Moon;* having completed her first quarter, *Half-Moon;* when she is in opposition she is called *Full Moon.*

Q. What relation does the Moon hold to the Earth?

A. It is the satellite of the Earth.

Q. How long does it take her to revolve around the Earth?

A. The time from one New Moon to another is 29 days, 12 hours, 44 minutes and 3 seconds.

Q. What is this revolution called?

A. It is called her Synodic revolution.

Q. What is her revolution from any fixed star to the same fixed star again called?

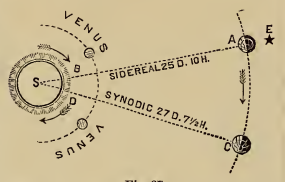


Fig. 27.

SIDEREAL AND SYNODIC REVOLUTIONS OF THE SUN.

Let S represent the Sun, and A the Earth in her orbit. When she is at A, a spot is seen upon the disc of the Sun at B. The Sun revolves in the direction of the arrows, and in 25 days 10 hours the spot comes round to B again, or opposite the star E. This is a *sidereal* revolution.

During these 25 days 8 hours, the Earth has passed on in her orbit some 25°, or nearly, to C, which will require nearly two days for the spot at B to get directly toward the Earth, as shown at D. This last is a *synodic* revolution. It consists of one complete revolution of the Sun upon his axis, and about 27° over.

A. It is called her Periodic or Siderial revolution.

Q. What time is required to perform this revolution?

A. It requires 27 days, 7 hours, 43 minutes and 11½ seconds.

Q. What is the difference between the length of a Synodic and a Siderial revolution?

A. The difference is one day and twenty hours.

Q. What causes the difference of time?

A. While the Moon is revolving around the Earth, she too is advancing in her orbit.

Q. Of all the heavenly bodies, which is nearest to the Earth?

A. The Moon is nearest.

Q. How near is she to the Earth?

A. She is only two hundred and forty thousand miles distant.

Q. How many revolutions does the Moon perform round the Earth in a year?

A. Nearly thirteen.

LESSON XXXI.

ANALYSIS. — Physical Aspect of the Moon — Appearance Variable — Cause of this — Appearance Through Telescope — Rough — Mountains — Compared to those of the Earth — Peculiar Formations — Ring Mountains — Description — Eclipses — Cause of Eclipse — Philosophical Cause Given.

PHYSICAL ASPECTS OF THE MOON.

Q. Is the Moon uniformly bright in appearance?

A. There are alternations of light and shade extending over the entire surface.

Q. What is the cause of this varied appearance?

A. These represent lofty and rugged mountains and deep valleys.

Q. How is this demonstrated?

A. The Moon, when viewed through a magnified telescope, in quadrature, presents on the line of light, a shade of a rough and jagged appearance.

LUNAR MOUNTAINS.

Q. What is the appearance of the mountainous regions of the Moon when compared with those of the Earth?

A. They equal, if they do not surpass, the rugged and precipitous ranges of our Globe — traversing the lunar surface in all directions.

Q. What peculiar mountain formation does the Moon possess?

A. They are called Ring mountains.

Q. How are these formed?

A. A deep cavern or crater is often seen on a plain, surmounted by a chain of mountains like a ring, and, frequently, from the center of this inclosed plain an isolated peak shoots up to a great height in the sky.

Ring Mountains.

Q. How do the mountains differ in appearance from other lunar mountains?

A. They are lofty mountains, circular in form, inclosing a vast area resembling the crater of a volcano.

Q. What is the extent of their diameters?

A. They are from ten to sixty miles in diameter.

Q. What other peculiarity in their formation?

A. They sometimes contain in their center one or more lofty peaks.

Q. What is observed flowing out from all sides of these Ring mountains?

A. There are seen streaks of light and shade radiating and spreading to a distance of several hundred miles.

Q. What are these called?

A. They are called *radiating streaks*.

Q. How are they accounted for?

A. They are considered by some to be streams of lava which have once flowed out in all directions from these volcanic mountains.

Q. For what is Copernicus distinguished?

A. It is one of the grandest of the Ring mountains.

Q. What is the length of its diameter?

A. It is fifty-six miles in diameter.

Q. What is there peculiar in its formation?

A. It has a central mountain, two of whose peaks are quite conspicuous.

Q. How high does it rise and what is its form?

A. It rises eleven thousand feet, and the summit is a narrow ridge, nearly circular in form.

Fig. 28.
Copernicus, from a drawing by Sir John Herschel.

Q. How does it appear in light of the Full Moon?

A. It is exceedingly brilliant, and sometimes resembles a string of pearls.

Q. What other of the Ring mountains is visible to the naked eye?

A. Tycho appears in the south-east quadrant of the Moon; is fifty-four miles across, and is sixteen thousand feet high.

The Eclipses.

Q. What is an Eclipse?

A. It is an obstruction or obscurity of the light of the Sun or Moon by the interposition of some dark body between them and our sight.

Q. What causes an Eclipse of the Moon?

A. When the Moon, in its revolution around the Earth, passes into its shadow, she suffers an Eclipse?

Q. What is the philosophical cause of an Eclipse?

A. A body always casts its shadow in the opposite direction from which the light strikes it; the Sun is the great source of light and is nearly one

million four hundred thousand times as large as the Earth, hence, owing to its immense size, the rays of light from the Sun would pass beyond the Earth, and at a distance of eight hundred and forty thousand miles would come together; and the diameter of the Earth being about eight hundred thousand miles, the shadow near its surface would also be about the same; but the Moon is only two hundred and forty thousand miles from the Earth; at that distance from the Earth, the shadow is only about six thousand miles broad, and as it assumes the form of a cone, it would terminate at a point where the rays of the Sun come together beyond the Earth—at a distance of eight hundred and forty thousand miles from it. The diameter of the Earth being eight thousand miles, hence, the Moon in passing around the Earth, when she comes into its shadow would become completely immerged in it and will have to move two or three times her whole diameter before she will emerge from the shadow into the light.

LESSON XXXII.

ANALYSIS. — Eclipse — When occur — Explained — When they cannot occur — Result, if the Orbits of the Earth and Moon were on the same Plane — Cause of an Eclipse of Sun — When only occur — Tides — How produced — Time of Spring Tides — Why? — Effect of Sun — That of Sun less than Moon — Why?

ECLIPSES.

Q. At what times only do we have an Eclipse of the Moon?

A. It can occur only at the time of a Full Moon.

Q. Why is this so?

A. Because the Moon can never get into the shadow of the Earth at any other time.

Q. Why do we not always have an Eclipse of the Moon at Full Moon?

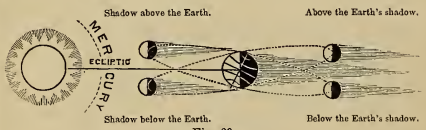


Fig. 29.
NEW AND FULL MOONS WITHOUT ECLIPSES.

A. The orbits of the Earth and the Moon do not lie on the same plane, hence the Moon may sometimes pass above or below the shadow of the Earth, then she will not suffer an Eclipse.

Q. What would be the result if the orbits of the Earth and the Moon lay on the same plane?

A. We should have an Eclipse of the Moon at every Full Moon, and an Eclipse of the Sun at every New Moon.

Q. What causes an Eclipse of the Sun?

A. The Moon, in passing around the Earth, when she gets between the Earth and Sun, her shadow being in the opposite direction from the Sun at that time, it can fall upon the Earth.

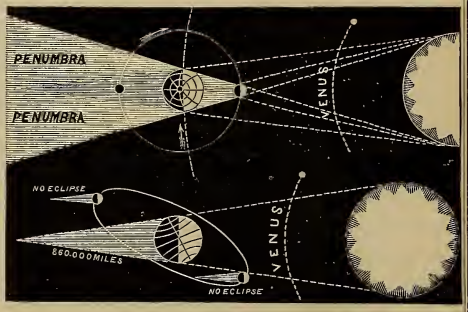
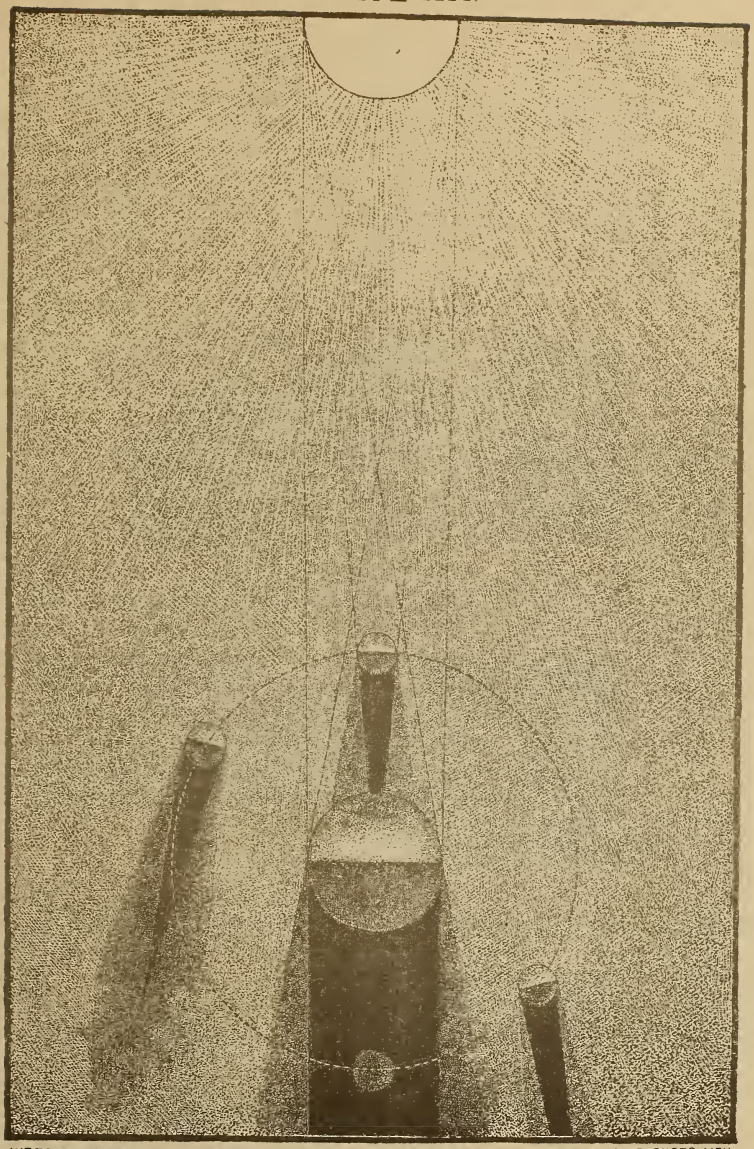


Fig. 30.
SOLAR AND LUNAR ECLIPSES.

PLATE XII.



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GENERAL THEORY OF ECLIPSES.

Q. Why do we have an Eclipse of the Sun only at New Moon?

A. At any other point in the orbit the shadow of the Moon would fall away from the Earth, hence, it would be impossible at any other time to have an Eclipse of the Sun.

ECLIPSES OF THE SUN.

Solar Eclipses are of three kinds. Some are total; the dark disc of the Moon then entirely covers the Sun. Others are partial; that is, a portion only, large or small, of the Solar disc is eclipsed. Lastly, there are annular, which take place when the disc of the Moon is not large enough to entirely cover that of the Sun, and leaves a luminous ring visible round its own body.

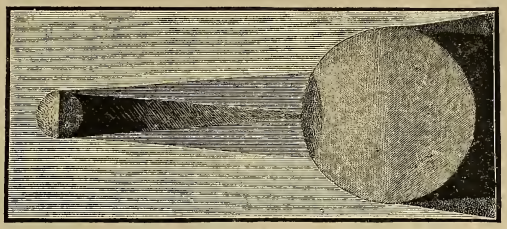

Fig. 31.
TOTAL ECLIPSE OF THE SUN.

As the Moon is much smaller than the Sun, it will be understood that it is its small relative distance which causes its disc to appear of equal and even greater dimensions than that of the Sun. This distance varies by reason of the elliptical form of its orbit, and hence the dimensions of the lunar disc are sometimes larger, sometimes smaller than, and sometimes equal to those of the Sun. If you turn to Fig. 31, you will witness a total Eclipse of the Sun. Here the dark shadow of the Moon falls on the Earth and obscures the entire body of the Earth.

Again, if the Cone of the Moon's shadow does not reach the earth, there will be annular eclipses visible in those parts comprised in the prolongation of the Cone; a partial eclipse to those which are only found in the penumbra. This case is represented by the next figure. (Fig. 32.)

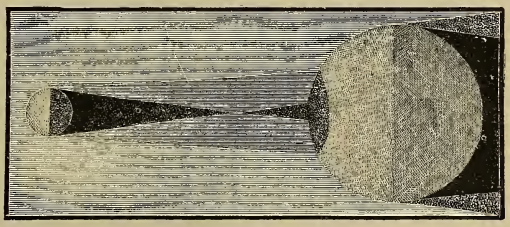

Fig. 32.
ANNULAR ECLIPSE OF THE SUN; THEORY.

It will be seen, therefore, that the conditions of the possibility of a total eclipse of the Sun are the following:

The Moon must be in conjunction, that is, she must be new;

She must at the same time be near a node;

Lastly, her distance from the Earth must be less than the length of the cone of shadow projected by her into space.

The same conditions, except the last, are necessary for an annular eclipse.

Q. How many solar eclipses do we generally have each year?

A. Two.

Q. What is the greatest number possible?

A. It is seven.

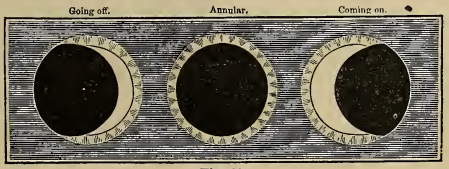

Fig. 33.
PROGRESS OF A CENTRAL ECLIPSE.

THE TIDES.

It is well known that twice a day at an interval of 12 hours and 25 minutes the shores of the ocean present us with the spectacle of the flow of the tide. The tide by degrees rises, gaining on the beach, which it covers to a greater and still greater height, and after six hours gains its maximum.

Fig. 34.

Scarcely is the instant of *high water* or *flood tide* attained then the flow or rise of the water ceases; the descent commences, and the *ebb* succeeds to the flow.

Q. What phenomenon results mainly from the the influence of the Moon?

A. The Tides.

Q. What causes the Tides?

A. The Earth attracts the Moon, and the Moon in turn attracts the Earth. The solid particles of matter composing the surface of the Earth not being free to move, the attraction of those particles is not perceptible by us, but the particles of matter composing the surface of the ocean being free to move, the attraction is perceivable, which causes the water to rise and form a wave. (See fig. 34.)

Q. At what time do we have spring tides?

A. At New Moon.

Q. Why?

A. The Moon is then between the Earth and Sun, and in range with them.

Q. How does that effect the Tides to make them higher?

A. The Sun and Moon, being on the same side of the Earth, and in range with it, the attraction of both acts together on the Earth. (See fig. 35.)

Q. What proportion do they attract?

A. The Moon causes the water to rise five feet, and the Sun causes it to rise another foot, making it six feet. It is then high tide on the side of the Earth toward the Moon and on the exact opposite of the Earth, while at the two sides of the Earth it is low tide.

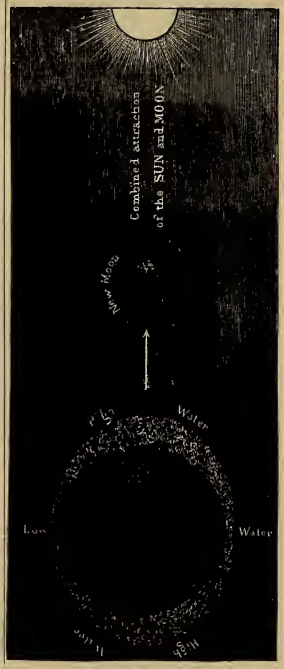

Fig. 35.

Q. Why does not the Sun exert a more powerful attraction upon the Earth, it being so much larger than the Moon?

A. The Moon is about 91,260,000 miles nearer the Earth than the Sun is at New Moon.

PLATE XIII.

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MARS AND THE EARTH.

COMPARATIVE DIMENSIONS.

LESSON XXXIII.

ANALYSIS.— Planet Mars — Location — Appearance ; To the Naked Eye — Distance from Sun — Time around it — Indication — Time of Revolution on Axis — Indication? — Diameter — Inclination — Exterior — Why? — Resemblance to Earth — Changes of Climate —Divisions of Land and Water — Geography Similar — Mars Probably Uninhabited — Circumference of Orbit — Distance from Earth — Opposition — Where looked for — Position of the Earth — Appearance of Mars.

THE PLANET MARS.

Q. Where is Mars located in the order of the Planets?

A. He is the fourth planet in the order of distance from the Sun, between the Earth and the Asteroids.

Q. What is its appearance?

A. To the naked eye it is distinguished for its brilliant red light.

Q. How far is this planet from the Sun?

A. The average distance is 145,205,000 miles from the Sun.

Q. How long does it take Mars to revolve around the Sun?

A. It takes 687 days.

Q. What does this indicate?

A. The length of his year.

Q. How long does it take to turn on its axis?

A. Twenty-four hours and forty minutes.

Q. What does this show?

A. The length of his day.

Q. What is his diameter?

A. It is 4,200 miles.

Q. What is the inclination of the plane of his orbit to that of the Ecliptic?

A. One degree and fifty-three minutes.

Q. Is Mars an interior or exterior planet?

A. He is an exterior planet.

Q. Why?

A. Because he lies wholly beyond the orbit of the Earth.

Q. To what globe has Mars a near resemblance?

A. The Earth.

Q. In what respects is this manifest?

A. In climates.

Q. Are there similar changes of cold and heat in Mars as in the Earth?

A. At certain seasons Winter scenes are presented, and at others, rain is apparent and the snow-caps disappear.

Q. Are there other analogies?

A. In divisions of seas and land.

Q. Any thing known of its geography?

A. It is nearly as well known and as well defined as that of the Earth. See Fig. 36.

Q. Is there evidence that Mars is inhabited?

A. The conditions of life on these planets are so unequal, it seems hardly possible or even probable, for Mars to be inhabited.

Q. What seems to confirm this position?

A. Mars receives but one half the amount of heat or light enjoyed on the Earth, hence, the apparent impossibility of human existence.

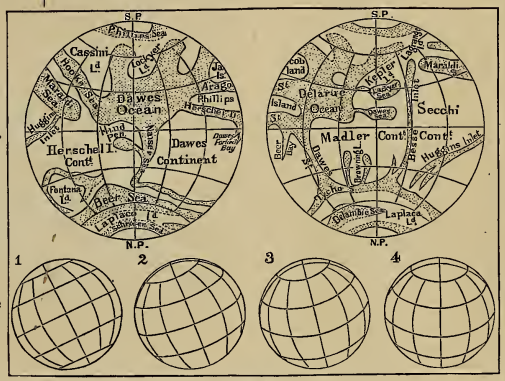


Fig. 36.

CHART OF MARS, FROM DRAWINGS BY MR. DAWES.

Q. What is the circumference of its orbit?

A. It is 901,064,000 miles.

Q. What is the mean distance of Mars from the Earth?

A. He is 50,000,000 miles.

Q. Is he then in conjunction or opposition?

A. In opposition.

Q. Which way do we look to see him?

A. In the direction opposite to the Sun?

Q. Then where would be the position of the Earth?

A. Between the Sun and Mars.

Q. At this time what is the appearance of Mars?

A. It appears with a surface twenty-five times larger than when in his conjunction?

LESSON XXXIV.

ANALYSIS.— When take place — Cause of brilliancy — Distance one side of Orbit — Inclination — Rate of Motion — Light, compared with that of Earth — Difference of Diameters — Density, compared with the Earth — Difference of Weight — Ratio from Sun of the Orbits of Planets described — Rapid Changes — White Spots — Snow Zones.

Q. When does this take place?

A. When he is in that part of his orbit beyond the Sun from the Earth and in range with them.

Q. When he is in his superior conjunction how far is he from the Earth?

A. He is 240,000,000 miles.

Q. Does this account for the changes in the size and brilliancy of the planet?

A. It does.

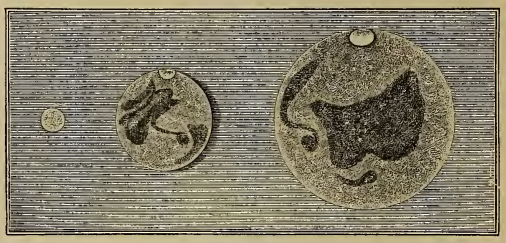


Fig. 37.

DIAMETER OF MARS AT EXTREME LEAST AND MEAN DISTANCES.

Q. How far is the Sun one side of the orbit of Mars?

A. He is 13,463,000 miles.

Q. What is the inclination of his axis to the plane of his orbit?

A. It is thirty degrees and eighteen minutes.

Q. What is Mars' rate of motion in his revolution around the Sun?

A. It is 54,640 miles an hour.

Q. What proportion of light falls upon Mars compared to that on the Earth?

A. About one-half as much.

Q. What is the difference between the polar and the equatorial diameter of Mars?

A. It is two hundred and sixty-three miles.

Q. What is the density of Mars compared with the Earth?

A. It is much less.

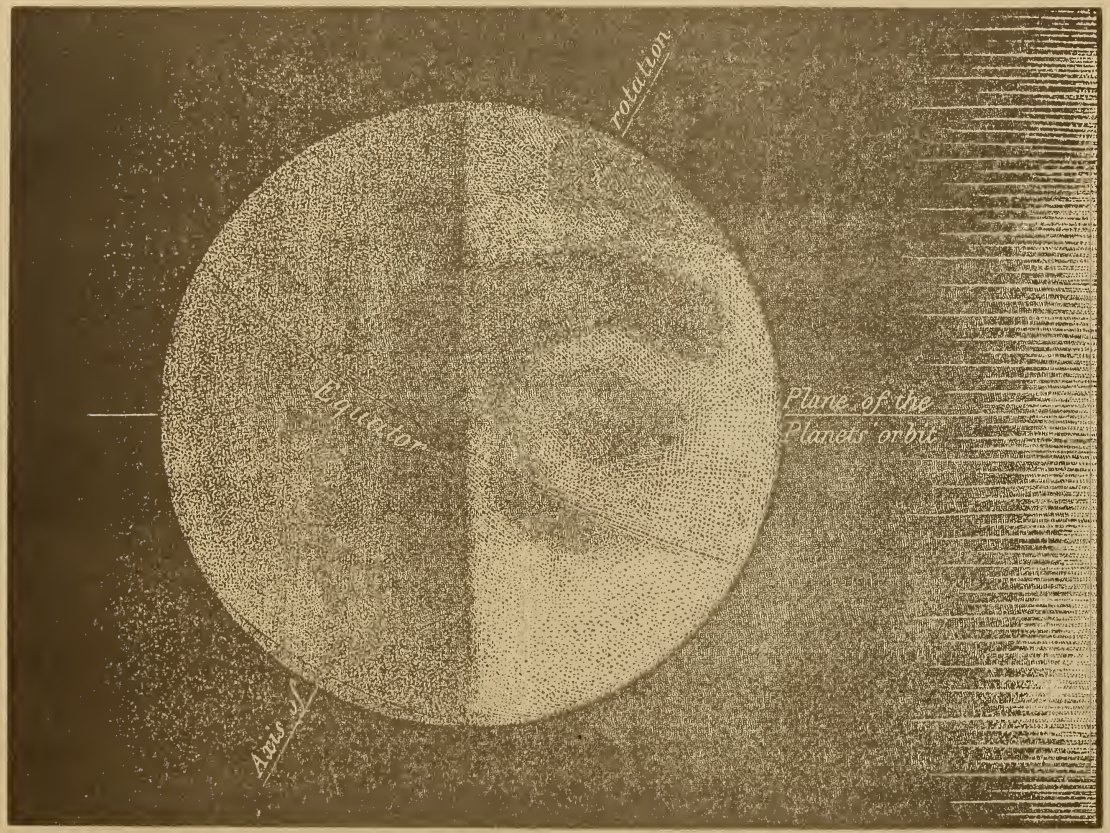
Q. How much would a body weigh on the planet Mars that weighs one pound on the Earth?

A. It would weigh 5 ounces and 6 drachms.

Q. What is the ratio of the distance from the Sun, of the orbits in which the planets already described move?

A. Venus' mean distance is about twice as far as Mercury; that of the Earth twice as far as Venus, and the mean distance of Mars twice as far as the Earth.

PLATE XIV.



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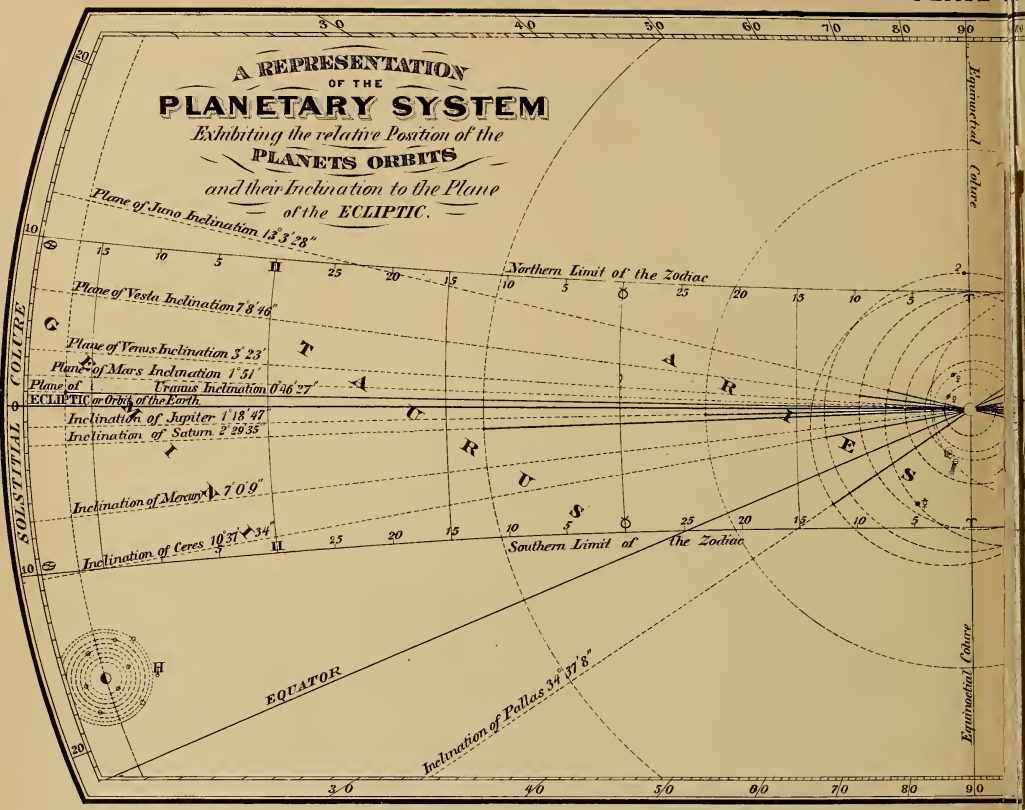
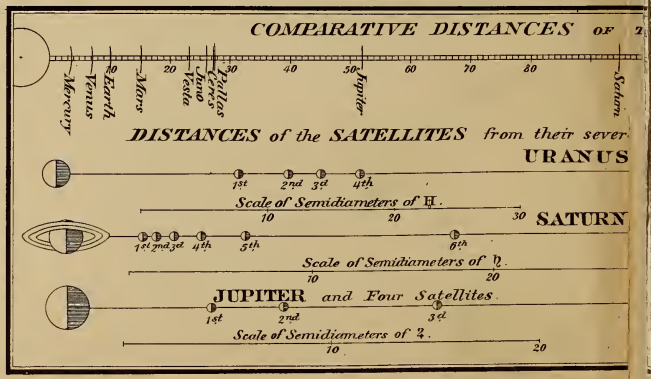
A. TOLLE, PHOTO-LITH.

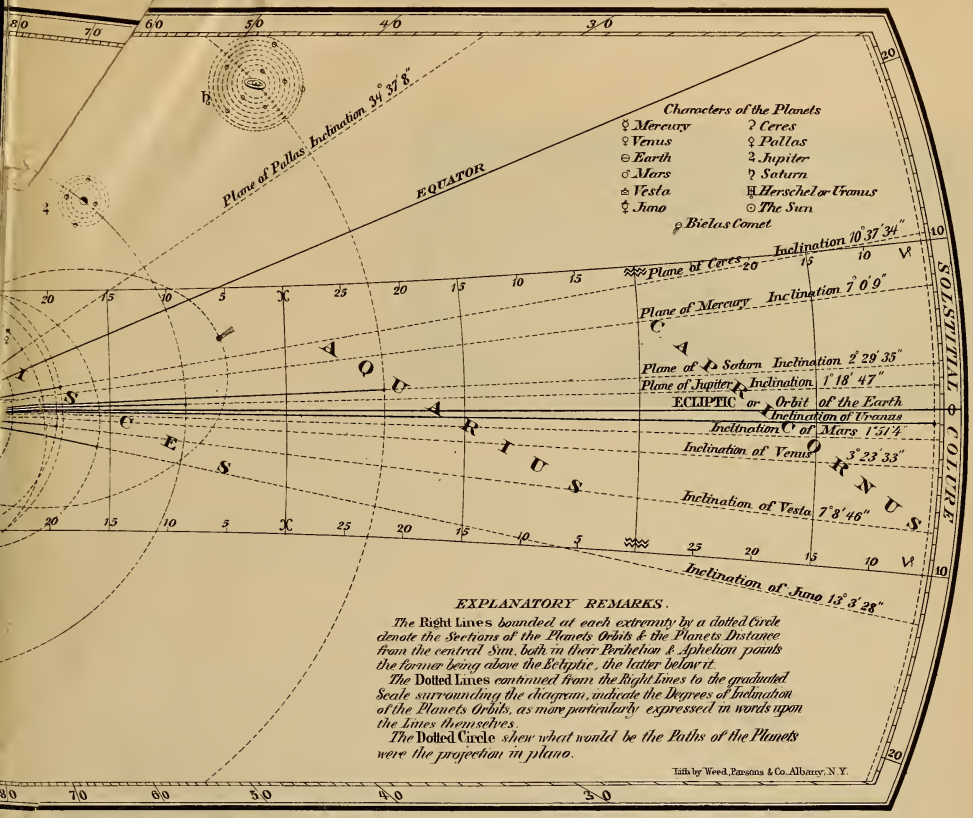
INCLINATION OF THE AXIS OF ROTATION.

MARS AT ONE OF ITS SOLSTICES.


A REPRESENTATION
OF THE
PLANETARY SYSTEM
Exhibiting the relative Position of the
PLANETS ORBITS
and their Inclination to the Plane
of the ECLIPTIC.
Plane of Juno Inclination 13°3'28"
Plane of Vesta Inclination 7°8'46"
Plane of Venus Inclination 3°23'
Plane of Mars Inclination 1°51'
Plane of Uranus Inclination 0°46'27"
ECLIPTIC or Orbit of the Earth
Inclination of Jupiter 1°18'47"
Inclination of Saturn 2°29'35"
Inclination of Mercury 7°0'9"
Inclination of Ceres 10°37'34"
Northern Limit of the Zodiac
Southern Limit of the Zodiac
Inclination of Pallas 34°37'8"
EQUATOR
SOLSTITIAL COLURE
Equinoctial Colure
Equinoctial Colure
GEMINI
TAURUS
ARIES
PISCES


COMPARATIVE DISTANCES OF
Mercury
Venus
Earth
Mars
Vesta
Juno
Ceres
Pallas
Jupiter
Saturn
DISTANCES of the SATELLITES from their sever
URANUS
1st 2nd 3d 4th
Scale of Semidiameters of ♅.
SATURN
1st 2nd 3d 4th 5th 6th
Scale of Semidiameters of ♄.
JUPITER and Four Satellites
1st 2nd 3d
Scale of Semidiameters of ♃.

IV.



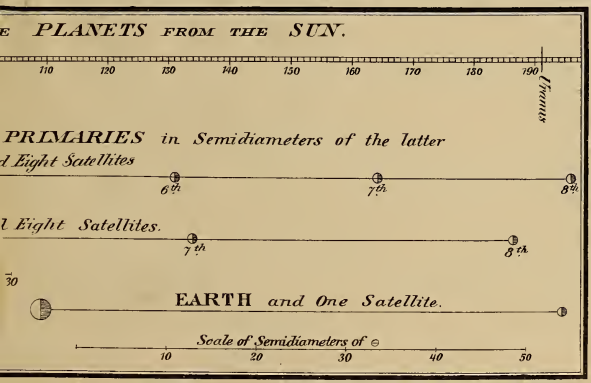
EXPLANATORY REMARKS.

The **Right Lines** *bounded at each extremity by a dotted Circle denote the Sections of the Planets Orbits & the Planets Distance from the central Sun, both in their Perihelion & Aphelion points the former being above the Ecliptic, the latter below it.*

The **Dotted Lines** *continued from the Right lines to the graduated Scale surrounding the diagram, indicate the Degrees of Inclination of the Planets Orbits, as more particularly expressed in words upon the Lines themselves.*

The **Dotted Circle** *shew what would be the Paths of the Planets were the projection in plano.*

Edits by Weed, Parsons & Co. Albany, N.Y.



SOLSTITIAL ☉ COLURE

There are constant and rapid changes going on, as in Fig. 38. You perceive the change manifest in an interval of two hours. These changes in the brightness of the disc are owing, it is supposed, to the variations of the clouds of vapor in its atmosphere.

No mountains have yet been discovered. In the region of the poles are brilliant white spots, which are supposed, by some, to be masses of Snow. These *Snow Zones* recede in summer and increase on the approach of winter.

Hence, we can observe in fact most, if not all, the changes of the seasons which take place on the surface of our neighboring planet.

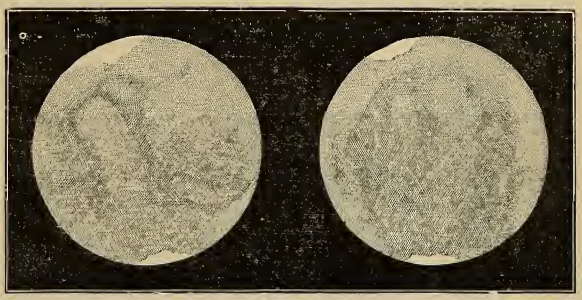


Fig. 38

VIEWS OF MARS AT TWO HOURS' INTERVAL. (WARREN DE LA RUE.)

Q. What small planets lie between Mars and Jupiter?

A. They are the Minor Planets.

LESSON XXXV.

ANALYSIS.— The Minor Planets — What are they? — Number — Space occupied — Kepler's impression — Not witnessed in his Day — Two Hundred Years after — Discovery Made — Four Found — CERES, PALLAS, JUNO and VESTA.

THE MINOR PLANETS.

Q. Where are the Minor Planets?

A. There are a large number of Minor Planets lying between Mars and Jupiter.

Q. How many do they number?

A. There are now known to be one hundred and thirty-four Minor Planets.

Q. How large a space do they occupy?

A. Not less than 35,000,000 miles.

Q. What impression was made on the mind of Kepler in view of this unoccupied space?

A. He was of opinion that within that space there must lie an undiscovered planet.

Q. How long after his day before a thorough research was made?

A. Some two hundred years.

Q. Who commenced it?

A. Twenty-four Scientific Explorers, in 1800, commenced a search for the hidden planet.

Q. Who was the first to detect the new planet?

A. It was an Italian astronomer by the name of Piazzi, in 1801, and called it Ceres.

Q. What effect did this discovery produce on the Scientists of that day?

A. It gave a new impulse to astronomical investigations.

Q. What was the result?

A. Not simply one but four were discovered.

Q. What were they named?

A. They were called Ceres, Pallas, Juno and Vesta.

LESSON XXXVI.

ANALYSIS.—Ceres — Time and by whom discovered — Estimate by Sir W. Herschell — Diameter — Distance from Sun — Time around it — Inclination — Appearance in Size and Color — Pallas — Time and by whom Discovered — By whom Measured — Distance from Sun — Time around it — Inclination — Appearance as to Size and Color — Juno — Time and by whom Discovered — By whom Estimated — Appearance as to Size and Color — Distance from Sun — Time around it — Inclination of Orbit — Vesta — Time when and by whom discovered — Comparison with the other Minor Planets — Diameter — Distance from Sun — Time of Revolution — Inclination of Orbit — Description of all nearly the same.

CERES.

Q. In what year and by whom was Ceres discovered?

A. In the year 1801, by Professor Piazzi, an Italian astronomer of Palermo.

Q. Who has given the most accurate estimate of this planet?

A. Sir Wm. Herschell.

Q. What is its diameter?

A. It is 163, miles.

Q. What is her mean distance from the Sun?

A. It is 262,764,110 miles.

Q. How long does it take to revolve around the Sun?

A. It takes about 1680 days.

Q. What is the inclination of her orbit to the plane of the Ecliptic?

A. It is ten degrees and thirty-seven minutes.

Q. What is its general appearance as to color and size?

A. This planet shines with a pale, reddish lustre, and like a star of the eighth magnitude.

PALLAS.

Q. At what time and by whom was this discovered?

A. On the 28th of March, 1802, by Dr. Olbris.

Q. Of whom has been received the most reliable measurement of this planet?

A. It has been given by Dr. Lamont of Munich.

Q. What is its mean distance from the Sun?

A. It is 263,186,670 miles.

Q. What is the time of its revolution?

A. It is one thousand six hundred and eighty-four days.

Q. What is the inclination of the plane of its orbit with the plane of the Ecliptic?

A. It is thirty-four degrees thirty-seven minutes and twenty seconds.

Q. What is its appearance as to size and color?

A. It shines like a star of the seventh magnitude and is of a yellowish light.

JUNO.

Q. Who discovered Juno, and in what year?

A. It was discovered by Professor Harding, of Lilienthal, on the 1st of September, 1804.

Q. What is its appearance as to size and color?

A. This planet shines as a star of the eighth magnitude and is of a reddish color.

Q. What is its mean distance from the Sun?

A. It is 253,524,410 miles.

Q. What is the time of its revolution around the Sun?

A. It is one thousand five hundred and thirty-two days.

Q. What is the inclination of the plane of its orbit to the plane of the Ecliptic?

A. Thirteen degrees three minutes and seventeen seconds.

VESTA.

Q. At what time and by whom was Vesta discovered?

A. She was discovered by Dr. Olbris, on the 29th of March, 1807.

A. How does she compare with the minor planets?

A. She is a small planet of the sixth or seventh magnitude, yet, when she appears in opposition to the Sun, she appears the brightest of all the Minor Planets.

Q. What is her diameter?

A. She is only 295 miles in diameter.

Q. How far is she from the Sun?

A. She is 224,327,205 miles.

Q. What is the period of her revolution?

A. It is one thousand three hundred and twenty-five days.

Q. What is the inclination of the plane of her orbit to that of the Ecliptic?

A. It is seven degrees eight minutes and twenty-five seconds.

NOTE.—The Minor Planets are so nearly similar, that it is unnecessary to speak further of them separately.

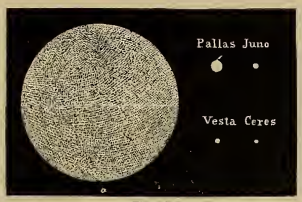


Fig. 39.
COMPARATIVE DIMENSIONS OF THE EARTH AND JUNO, CERES PALLAS AND VESTA.

The four planets of which we have just given some details, are among the most important of the group. The smallness of nearly all the others is such that it is not possible to measure their diameters, as they appear in a telescope merely as luminous points. It is probable that the least of these microscopic bodies have diameters which do not reach many score miles, and that a good walker could easily in a day make a tour of many of these miniature worlds.

Q. How long shall we go on making discoveries of fresh bodies in this zone between Mars and Jupiter?

A. This is a difficult question to solve, but it is probable that we are now acquainted, if not with the largest of the Minor Planets, at all events with all those most easily visible from the Earth. The discovery of others will, therefore, become more and more difficult, and the extension of their number is partly subordinate to the use of larger instruments in the research, and more detailed celestial maps. At all events, M. Leverrier, from mathematical considerations, has assigned to the total mass of the bodies which compose the ring, such a limit, that if we suppose them to possess a density equal to that of our own globe, those already discovered form only the $\frac{1}{1800}$th part of it. This would make the number of the Minor Planets about 150,000. But, admitting that this number may be excessive, and in reducing it to the tenth of its value, this swarm of celestial bodies will still be counted by thousands.

JUPITER.

From that region of space where we have just seen the smallest members of our system circulating in their orbits, we pass without transition to the largest planet — the colossal Jupiter.

To the naked eye, Jupiter appears as a star of the first magnitude, the brightness of which, variable with its distance from the Earth, is sometimes, when the Moon is absent, sufficient to throw a shadow. Its light is constant, and scintillates but rarely. But if, to examine it, a rather powerful telescope is used, the point expands into a well-defined disc, and is generally seen to be accompanied by three or four little points of light which oscillate in short periods of time round the central planet: These are the Satellites of Jupiter.

Venus, Mercury and Mars, as we have seen,

are without satellites; the Earth has only one. Jupiter with its four moons, which the powerful attraction of its bulk compels to revolve round him, exhibits to us, therefore, a small system analogous to the solar one of which it forms part and which it reproduces on a smaller scale.

To arrive in our journey from the Sun as far as the Jovian system, we must pass over a distance which exceeds five times the mean distance of the Sun from the Earth, or, in the mean, 500,000,000 miles. But the orbit described by Jupiter round the Sun differs from the circular form more than does the Earth's. Its distance, therefore, is more variable, and while at Perihelion it reaches 472,000,000 miles, at its greatest distance it is not less than 520,000,000 miles from the Sun, hence the difference being 48,000,000 miles.

Jupiter, therefore, as seen from the Sun, presents an apparent diameter sometimes greater, sometimes less than its mean one; and, of course, the same phenomenon is seen by observers situated on the Earth, but in a much greater proportion. Fig. 40 will give an idea of the variations

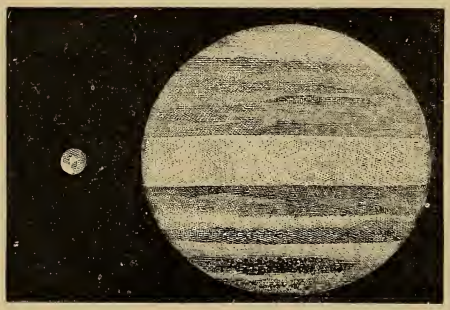


Fig. 40.

JUPITER'S MEAN AND EXTREME DISTANCES FROM THE EARTH.

of size which the disc of Jupiter, at the time of its mean and extreme distances from the Earth, presents to us.

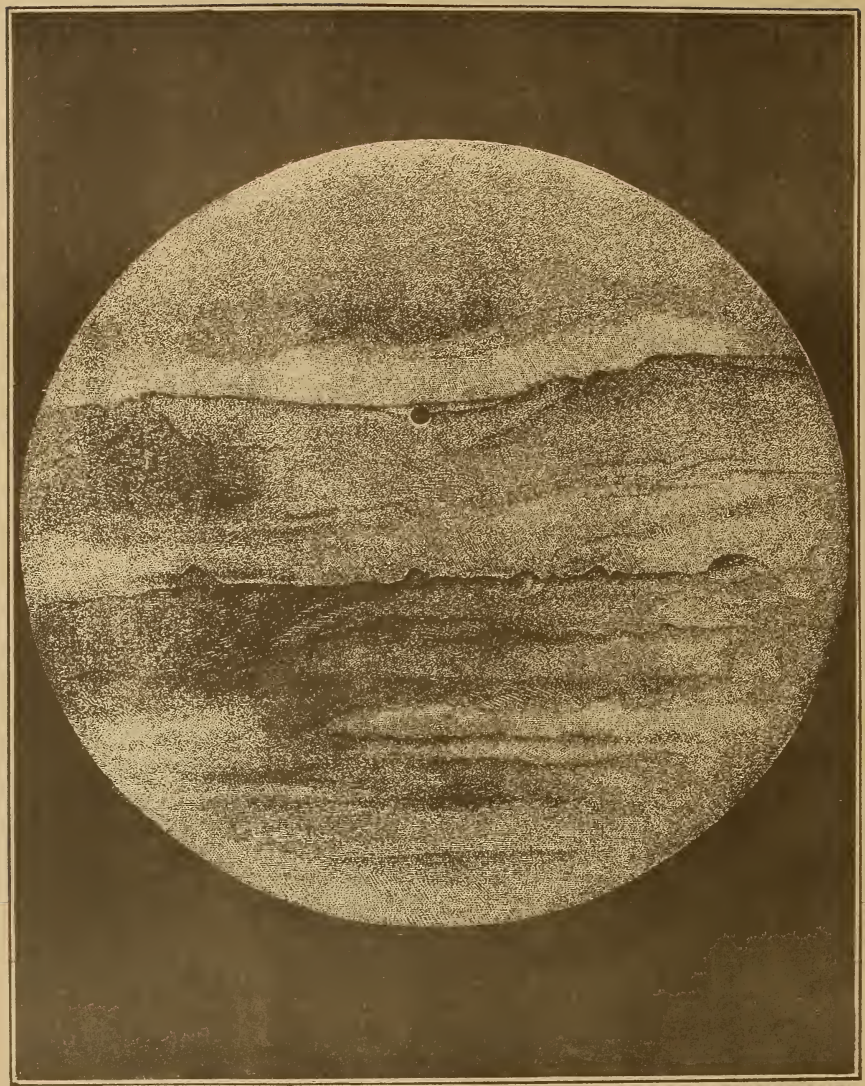
The reason of this difference between the apparent diameters of the disc is easily explained. The orbit of Jupiter, like that of Mars, encircles the terrestrial one, and the motions of the two bodies in their respective orbits bring them, once in every thirteen months, in the same straight line with the Sun, and on the same side of it; Jupiter is then in *opposition*, and its distance from the Earth is measured by the difference of the distances of the two bodies from the Sun. In a similar period the two planets are still in a straight line with regard to the Sun, but on opposite sides of it. This is the *conjunction* of Jupiter, and the distance of the two planets is found by adding their respective distances from the Sun. These distances themselves are sometimes smaller and sometimes greater than at others, and therefore the same thing happens with regard to those which separate the Earth from Jupiter at the time of *opposition* and *conjunction*.

At its greatest distance from the Earth, Jupiter is 617,000,000 miles from us; at opposition it may be within 375,000,000 miles; but in the mean, the distance of Jupiter at conjunction with the Sun is 591,000,000 miles, and at opposition 400,000,000 miles, the difference being the diameter of the Earth's orbit.

From the preceding numbers we may perceive the immense development of the orbit described by this member of our planetary system. Thus, to traverse this path, it requires twelve years. This gives a mean rate of upwards of 700,000 miles a day, or nearly 30,000 miles an hour.

The movements with which we are acquainted on the Earth can give us no idea of such a mass traveling eternally through the depths of space with a velocity eighty times greater than that of a cannon ball.

PLATE XV.



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JUPITER.

Bright and dark belts, transit of a Satellite and its shadow across the disk

LESSON XXXVII.

ANALYSIS.— Planet Jupiter — Situation — Why Distinguished — Distance from the Sun — Time around it — Indication — Diammeter — Time of Revolution on its Axis — Indication — Circumference of Orbit — Rate of Motion — Effect of Motion on the Weight of Bodies on his Surface — Weight of Bodies on his Surface compared with their Weight on the Earth — Cause of Difference — Satellites — Variable Appearance — Observations of Mr. Dawes.

JUPITER.

Q. What planet lies next to the Minor Planets in the regular order from the Sun?

A. It is Jupiter.

Q. For what is Jupiter distinguished?

A. He is regarded the largest and most magnificent planet of the Solar System.

Q. How far is Jupiter from the Sun?

A. He is 495,817,000 miles.

Q. How long does it take this planet to make a revolution around the Sun?

A. It takes him 4,332 days 14 hours and 2 minutes, or nearly 12 years.

Q. What does this indicate?

A. The length of his year.

Q. What is the mean diameter?

A. It is eighty-nine thousand miles.

Q. How long does it take Jupiter to turn on his axis?

A. It takes 9 hours and 56 minutes.

Q. What does this show?

Q. The length of his day.

Q. What is the circumference of this orbit?

A. It is 3,110,000,000 miles.

Q. What is his rate of motion?

A. It is estimated at 30,000 miles an hour.

Q. What is said of his motion on his axis?

A. It is said to be greater than that of any other planet in the Solar System.

Q. What effect does this rapid motion on his axis have upon the weight of bodies on his surface?

A. It makes them lighter than they would be were its motion no greater than that of the Earth.

Q. What is the weight of bodies on the surface of Jupiter compared with their weight upon our Earth?

A. A body that weighs one pound upon the Earth at the Equator, would weigh two pounds four ounces and a half on the Equator of Jupiter.

Q. What causes the difference?

A. The immense size of Jupiter.

SATELLITES.

Four luminous points — four small stars — unceasingly accompany Jupiter in its twelve-yearly revolution. They are easily observed with small telescopes.

From hour to hour their positions vary, and they seem to oscillate from one side to the other of the disc, in paths nearly parallel to the direction of the belts, that is to say, to the equator of Jupiter. These are its moons or satellites. They are besides frequently seen to disappear, one, two, and even three at a time. It sometimes, indeed, even happens that not one of the four is visible. Jupiter then appears alone, deprived of its companions. This state of things was observed by Mr. Dawes, on the 27th of September, 1843. But it only happens very rarely.

LESSON XXXVIII.

ANALYSIS.— Satellites of Jupiter — Number — Names — Diameters — Distances — and Revolutions — Eclipses — Number per Month — Eclipse of Sun effected by them — Inclination of the Axis of Jupiter to Plane of his Orbit — Plane of Orbit to Plane of Ecliptic — Eccentricity of Orbit — Solar heat compared with Earth.

Fig. 41.
JUPITER AND ITS FOUR SATELLITES.

Q. How many satellites has Jupiter?

A. Four.

Q. What are they called?

A. Io, Europa, Ganymede and Callisto.

Taking these satellites in the order of their distances, the times of their revolutions are as follows:

First satellite	(Io)	. . .	1 day,	18 hours,	28 minutes.
Second "	(Europa)	. 3 "	13 "	43 "
Third "	(Ganymede)	7 "	3 "	43 "
Fourth "	(Callisto)	. 16 "	16 "	32 "

In comparing these times with that of the revolution of the Moon, it is seen that the movements of the satellites of Jupiter are much more rapid than that of our Moon. This rapidity is the more marked, as their distances from the planet, and, therefore, the lengths of their orbits are more considerable than in the case of our satellite. Measured from the center of the planet, the mean distances of these satellites are as follows:

Q. What are their respective diameters, distances and periods of revolution around their primary?

A.	Diameter. Miles.	Distance. Miles.	Revolution. Days.	H'rs.	Min.	Sec.
Io . . .	2,440	278,500	1	18	27	34
Europa .	2,190	443,000	3	13	14	36
Ganymede	3,580	707,000	7	3	42	33
Callisto .	3,060	1,243,500	16	16	31	50

Lastly, as mentioned, above, it may happen that during the disappearance of the three satellites, the fourth is between the Earth and the planet. Then the planet equally appears solitary and deprived of its companions.

Fig. 42 will render clear the various positions which the satellite may occupy with reference to the Earth. One of them in this figure is represented Eclipsed, the other is seen projected on the disc, on which also its shadow is thrown; a third is hidden by the planet, and the fourth is entirely visible.

Fig. 42.
DIMENSIONS OF THE SATELLITES OF JUPITER COMPARED WITH THOSE OF THE EARTH AND MOON.

We have seen what are the apparent dimensions of the four satellites as seen from Jupiter, compared to the apparent size of our Moon. But we must not confound the apparent with the real diameters. (See the above table of diameters.) So, the third and fourth in the order of distance are the first and second in order of magnitude; one only is less than our Moon; taken together, they would form a body 9½ times larger than it, or about one-fifth of the volume of the Earth.

Lastly, the volume of the largest exceeds by

two-thirds the volume of the planet Mercury. Here, then, we have a secondary body larger than a primary one of the first order, and far surpassing in size those which circulate between Mars and Jupiter.

Eclipses of these Satellites.

Q. How many Eclipses do they suffer every month?

A. The first suffers eighteen; the second, eight or nine; the third, about four. The fourth does not suffer as much as either of the other three, as it frequently passes its opposition without being involved in the shadow of Jupiter.

Q. When either or all of them are between Jupiter and the Sun, what takes place?

A. Their shadows fall upon the planet as they come between it and the Sun, causing an eclipse of the Sun.

Q. How many can cause an eclipse at a time?

A. All of them can never be eclipsed or cause an eclipse at the same time; seldom ever but two of them.

Q. What is the inclination of Jupiter's axis to the plane of his orbit?

A. Eighty-six degrees and fifty-four and a half minutes, or three degrees and five and a half minutes from the perpendicular.

Q. What is the inclination of the plane of his orbit to the plane of the ecliptic?

A. One degree and nineteen minutes.

Q. What is the eccentricity of the orbit of Jupiter?

A. It is 23,810,000 miles.

Q. What is the intensity of its solar heat when compared with the heat of the Earth?

A. It is twenty-seven times less.

LESSON XXXIX.

Analysis.— Observations of Astronomers — Appearance of Belts — What known — Situation — How esteemed by Astronomers — Uniformity considered — Other peculiarity of appearance — Accounted for — Difference of Jupiter's Diameters.

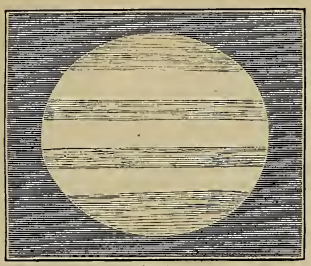

Fig. 43.
TELESCOPIC VIEW OF JUPITER.

Q. What has been particularly observed by astronomers relative to the planet Jupiter?

A. On certain occasions as many as eight belts have been seen, at others only one.

Q. What is the appearance of these belts?

A. They appear like dark stripes across the disc of this planet.

Q. What is known of these belts?

A. They are known to vary as to their number, distance from each other and their positions.

Q. How do they appear to be situated?

A. Parallel to one another and to the equator of Jupiter.

Q. How are these regarded by astronomers?

A. They are esteemed by some to be openings in the luminous atmospheric envelope of Jupiter, by others that openings betray the dark surface of the planet, and that glimpses thus caught of the solid body constitute the narrow, dusky belts or bands.

Q. Are they at all times the same in length and width?

A. They continue for months without variation, and a new belt is seen to form in a few hours; sometimes they decrease in length and then increase in width until they run into each other to the extent of five thousand miles in breadth.

Q. What other peculiarity is manifest in their appearance?

A. There are at times seen bright and dark spots in these belts, which usually disappear with the belts, sometimes they continue. Cassini observed one in the same position for forty years.

Q. How are these belts and spots accounted for?

A. They are regarded as nothing more than atmospheric phenomena resulting from the rapid motion of the planet on its axis.

Q. What is the difference between the Equatorial and the Polar diameters of Jupiter?

A. The Equatorial is sixty-three hundred miles the longer.

LESSON XL.

ANALYSIS.— Saturn — Situation — Distance from Sun — Time round it — Indication — Diameter — Revolution on Axis — Indication — Inclination of Axis to its Orbit — Inclination of Orbit to the Ecliptic — Eccentricity of its Orbit — Difference of Diameters — Solar Light compared with that of Earth — Rate of Motion — Density — Difference of Weight — Why one of the most magnificent Planets — Rings and Moons.

SATURN.

Q. Where is the planet Saturn situated?

A. Next to Jupiter, in the order of distance from the Sun, and between the orbits of Jupiter and Uranus.

Q. What is the distance of Saturn from the Sun?

A. It is nine hundred and seven million miles.

Q, What is the diameter of this planet?

A. It is seventy-nine thousand miles.

Q. How long does it take to make a revolution around the Sun?

A. It takes twenty-nine and a half years.

Q. What does this show?

A. It indicates the length of its year.

Q. How long does it take Saturn to turn on its axis?

A. Ten hours and sixteen minutes.

Q. What does this indicate?

A. The length of her day.

Q. What is the inclination of its axis to the plane of its orbit?

A. It is perpendicular.

Q. What is the inclination of its orbit to the plane of the Ecliptic?

A. Two degrees and twenty-nine and a half seconds.

Q. What is the eccentricity of its orbit?

A. It is forty-nine million miles.

Q. What is the difference between its Equatorial and Polar diameters?

A. The Equatorial is six thousand and seven hundred miles longer than its Polar.

Q. What proportion of solar light does this planet receive compared with that of the Earth?

A. It is about one-nineteenth part of the amount of light.

Q. What is its rate of motion?

A. It is twenty-two thousand miles an hour.

Q. What is the density of this planet?

A. It is about as great as cork.

PLATE XVI.

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SATURN.

From Observations of Bond, Struve and Warren De La Rue. Nov. 1852, and Mar. 1856.

LESSON XLI.

ANALYSIS.— Rings of Saturn — Situation of them — Revolution — Detached — How known to be Separate — Distance from Planet to Interior Ring — Breadth of it — Width between Rings — Thickness of Rings — Consists of what — How determined — Importance of them to the planet.

Q. A body that weighs one pound on the surface of the Earth would weigh how much on the surface of Saturn?

A. One pound and four drachms.

Q. How much would a body that weighs one pound on the surface of the Earth, at the equator, weigh if transported to the Sun?

A. It would weigh about twenty-seven and a half pounds.

Q. Why is the planet Saturn considered one of the most magnificent and interesting objects in the planetary system?

A. It is attended with eight moons and a suite of gorgeous rings.

RINGS OF SATURN.

Q. How are the rings of Saturn situated in regard to each other and to the planet?

A. They are concentric, or one lies between the other and the planet, and they are over the equator of the planet.

Q. How do they revolve?

A. On their axis and in the same time.

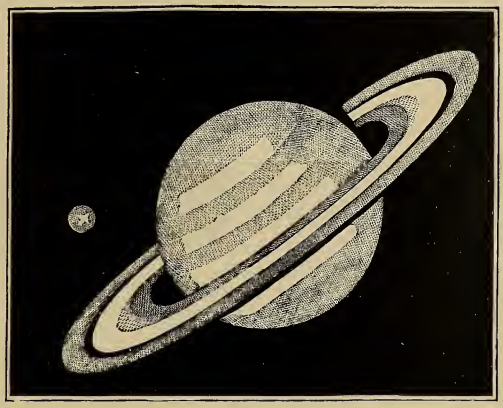


Fig. 44.
SATURN AND THE EARTH; COMPARATIVE DIMENSIONS.

Q. How do we know they are separate or wholly detached from each other?

A. The fixed stars have been seen in the distant heavens through the openings between them and between the planet and the first ring.

Q. What is the distance from the planet to the interior ring?

A. It is thirty-three thousand and six hundred and fifty miles.

Q. What is the breadth of the interior ring?

A. It is nineteen thousand and fifty miles.

Q. What is the width of the opening between the two rings?

A. It is two thousand and nine hundred miles.

Q. What is the breadth of the exterior ring?

A. It is seven thousand and three hundred miles.

Q. What is the thickness of the rings.

A. They are not more than one hundred miles in thickness.

Q. Of what do they consist?

A. Various opinions are entertained as to their composition; some that they are a solid compact substance, and others that they are fluid.

Q. What reason have they for the latter conclusion?

A. It is the fact they are almost infinitely divided.

Q. What importance are they to the planet?

A. They serve to reflect light upon its surface.

LESSON XLII.

ANALYSIS.— Circles not True — Centers coincide with the Center of Planet — Gravity of These Rings — Importance to the Stability of the System of Rings — Moons of Saturn — Number — Seldom Seen — Revolve with the Rings — Respective Distances from Saturn — Inclination of their respective Orbits to the Plane of Saturn — Eclipses of these satellites — Seldom Suffer — Respective Sizes.

Q. Are they in true circles?

A. They are not exactly.

Q. Does the center of their rings coincide with the center of the planet.

A. It does not exactly.

Q. What is known of their centers of gravity?

A. The center of gravity of these rings oscillates around that of the planet, describing a small orbit.

Q. What importance is this to the stability of the system of rings?

A. It prevents the rings from being shifted from their equilibrium by any external force or attraction of other heavenly bodies.

We give below the names of the eight moons of Saturn, with their distances from the center of the planet, and the time of their revolution in terrestrial mean solar days:—

	Distance from Saturn's Center in Miles.	Time of Sidereal Revolution. Days	Hrs.	Min.	Sec.
Mimas	119,725	0	22	37	23
Enceladus	153,630	1	8	53	7
Tethys	190,225	1	21	18	26
Dione	243,670	2	17	41	9
Rhea	340,320	4	12	25	11
Titan	788,915	15	22	41	25
Hyperion	954,160	21	7	7	41
Japetus	2,292,790	79	7	54	40

The first four satellites are all nearer to Saturn than the Moon is to the Earth. Mimas is, moreover, but 82,000 miles from Saturn's surface, and Dione about 206,000; Mimas' distance from the edge of the ring being but about 31,000 miles. On the other hand, Japetus is nearly ten times more distant from Saturn than we are from our satellite, so that the diameter of the Saturnian system measures nearly 4,500,000 miles.

THE MOONS OF SATURN.

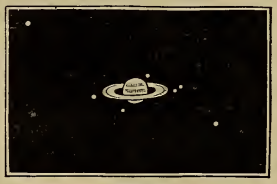


Fig. 45.

SATURN AND ITS SATELLITES. (SIR JOHN HERSCHEL.)

Q. How many moons or satellites has Saturn?

A. Eight.

Q. Are they easily discovered?

A. They are only seen with good instruments and under favorable circumstances.

Q. When is the best time to take a view of them?

A. When the planet is at its Equinox, then the rings are nearly invisible.

Q. How do these satellites revolve?

A. They revolve eastward with the rings of the planets; in orbits nearly circular, and, with the exception of the eighth, in the plane of the rings.

Q. What are their respective distances from the planet?

A. The distances and periods of the satellites of Saturn are as follows:

PLATE XVII.

WEED, PARSONS & CO. ALBANY, N. Y. A. TOLLE, PHOTO-LITH..

URANUS AND THE EARTH.

COMPARATIVE DIMENSIONS.

	Distances in Mile	Periodic t'mes.					
Mimas . .	123,000	. 00 days,	22	hours.			
Enceladus .	128,000	. 1 "	8	"			
Tethys . .	196,000	. 1 "	21	"			
Dione . .	251,000	. 2 "	17	"			
Rhea . .	351,000	. 4 "	12	"	55	seconds.	
Titan . .	811,000	. 15 "	22	"	51	"	
Hyperion .	2,766,000	. 79 "	7	"	54	"	
Japetus . .	2,336,000	. 46 "	12	"	00	"	

Q. What is the inclination of their respective orbits to the plane of Saturn's orbit?

A. The orbits of the six inner satellites are inclined about thirty degrees; the other two about twenty-four degrees and forty-five minutes.

Q. What is known in regard to these satellites suffering eclipses?

A. They seldom suffer an eclipse, and they happen only when the rings are seen edgewise.

Q. What is the respective sizes of these satellites?

A. The two nearest to Saturn are the smallest, the third and fourth the next in size, the fifth and sixth are somewhat larger, the seventh and eighth are the largest. The eighth is about four thousand two hundred miles in diameter and turns on its axis, and it is probable all the others do the same.

LESSON XLIII.

ANALYSIS.— Uranus — Situation — Distance from Sun — Time of Revolution round the Sun — Diameter — Time of Revolution on Axis not known — Inclination of Orbit — Rate of Motion — Light compared with that of the earth — Density — Eccentricity of Orbit — Difference of the Weight of Bodies on the Earth and the Surface of Uranus — Satellites of Uranus — Number — Respective Distances and Periodic Times — Their Variation in Revolution — Size of them — Seldom suffer Eclipse.

URANUS.

Q. Where is the planet Uranus situated?

A. Uranus is the eighth planet in the order of distance from the Sun, its orbit lying between the orbits of Saturn and Neptune.

Q. How far is Uranus from the Sun?

A. It is 1,824,000,000 miles.

Q. How long does it take this planet to revolve around the Sun?

A. It takes eighty-four years.

Q. What is the diameter of Uranus?

A. It is thirty-five thousand miles.

Q. How long does it take to turn on its axis?

A. Owing to its immense distance from the Sun its diurnal motion has not as yet been ascertained.

Q. What is the inclination of its orbit to the plane of the ecliptic?

A. It is but very little inclined; forty-six minutes and twenty-six seconds.

Q. What is its rate of motion?

A. It is fifteen thousand miles an hour.

Q. What is the proportion of light of this planet compared with that on the Earth?

A. It is three hundred and sixty times less.

Q. What is the density of this planet?

A. About that of water.

Q. What is the eccentricity of its orbit?

A. It is eighty-five million miles.

Q. What would a body weighing one pound on the Earth's surface weigh if removed to the planet Uranus?

A. It would weigh fourteen ounces and fourteen drachms.

Satellites of Uranus.

Uranus, like Saturn, is the center of a little system, comprising, besides the principal planet, eight moons or satellites, revolving in planes

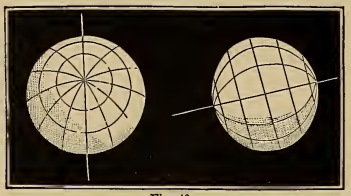


Fig. 46.

DIFFERENCE BETWEEN THE APPARENT FORMS OF A FLATTENED GLOBE, SEEN IN TWO DIFFERENT POSITIONS.

nearly perpendicular to the plane of the planet's orbit. These bodies, whose revolutions are accomplished, the nearest in two days, and the most distant in about 108 days, possibly compensate, in some degree, by their reflected light, during the nights of the planet, the feeble intensity of the daylight. The Sun is visible at Uranus as a small disc, whose superficial extent is but one 370th of the extent of the solar disc as seen from our globe. The heat received from it, too, is but one 370th of that we receive from the Sun.

We have shown in fig. 47, the relative dimensions of the orbits of the satellites, as they would be seen if we could obtain a bird's-eye view of the plane in which they revolve. We have already mentioned the fact that their movements are performed in a direction nearly perpendicular to the plane in which the planet revolves around the Sun. Another peculiarity, and this is found nowhere else throughout the solar system, further distinguishes Uranus — the direction of these movements is retrograde; that is to say, it is contrary to that of all the other known movements of satellites and planets. But this anomaly probably results from the very great inclination of their orbits, shown in fig. 47.

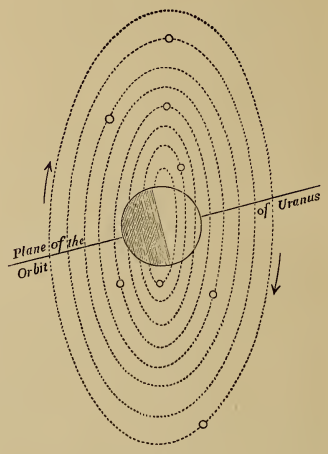


Fig. 47.

The first satellite is but 128,000 miles, or about half the distance of our Moon, from the planet. The most distant of the four of which we have certain knowledge is 392,000 miles. Of these four, the two nearest, *Ariel* and *Umbriel*, were discovered by Lassell and Otto Struve respectively; the six remaining ones (two of which have received the names *Titania* and *Oberon*), by Sir W. Herschel.

Q. How many satellites has Uranus?

A. It has eight?

Q. What is their respective distances and period of times?

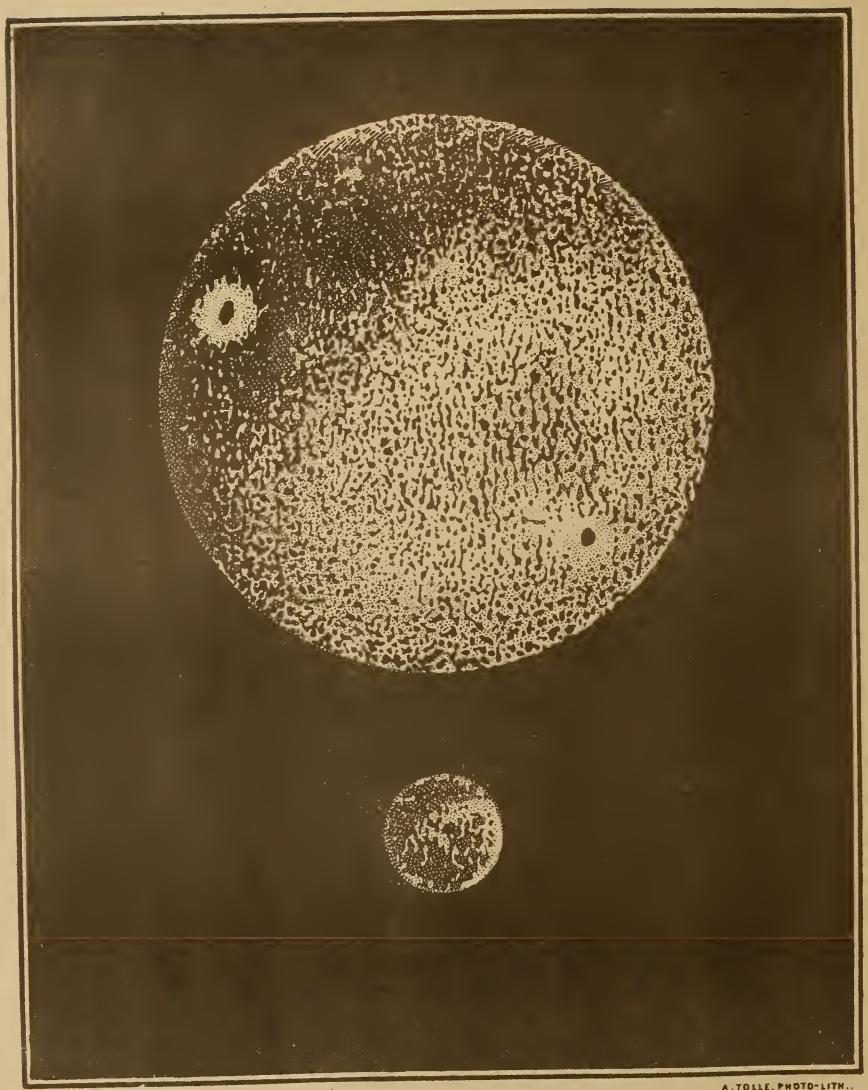
A.	Dist. in Miles.	Periodic Times. d.	h.	m.	s.		Dist. in Miles.	Periodic Times d.	h.	m.	s.
First Satellite	224,000	5	21	25	26	Fourth Satellite	390,000	11	10	56	29
Second "	296,000	8	16	57	47	Fifth "	777,000	38	48	34	00
Third "	340,000	10	23	2	47	Sixth "	1,556,000	107	16	39	56

Note.—Of the remaining two but little is known, and hence but little can be said.

Q. In what respect do the satellites of Uranus vary from the analogy of the motion of all the other satellites in our planetary system?

A. Their motions in their orbits are known to

PLATE XVIII.



WEED, PARSONS & Co, ALBANY.

A. TOLLE, PHOTO-LITH..

NEPTUNE AND ITS SATELLITE.

be retrograde, so that instead of advancing forward in their orbits from west to east around their primary, as other satellites do, they move in the opposite direction.

Q. What is known of the size of these satellites?

A. They have never been accurately measured, owing to their vast distance from the Earth, but were they not about three thousand miles in diameter they could not be seen.

Q. What is known of these satellites suffering an eclipse?

A. They seldom suffer eclipses, but may suffer two a year.

LESSON XLIV.

ANALYSIS.— Neptune — Situation — Orbit — Distance from Sun — Revolution round it — Diameter — Rate of Motion — Inclination of Orbit to the Ecliptic — Time on Axis unknown. One Satellite — Situation — Time around the Primary — Indication.

NEPTUNE.

Neptune is invisible to the naked eye. In telescopes, it has the aspect of a star of the eighth magnitude. Its apparent movement is extremely slow; but, as the orbit which it describes round the Sun is so immense, its real velocity is, nevertheless, considerable; it is about 12,400 miles an hour.

Like all other planets, it is sometimes nearer and sometimes further from the Earth. At the time of conjunction it is distant from us, on the average, 2,958,000,000 miles, whilst its minimum distance at opposition is less by 218,000,000 miles.

The real dimensions are somewhat considerable, and in virtue of them Neptune is the third planet of the system. Its diameter is 37,000 miles greater than the diameter of the Earth. The surface of the globe of Neptune is more than twenty-two times that of the Earth, and its volume is nearly 105 times.

The intensity of the heat and light received by that planet is but little more, at that enormous distance, than the thousandth part of that received by us. But, as nothing is known of its physical and atmospheric conditions or of its rotation, nothing can be determined on the climatic conditions of the planet.

At a distance nearly equal to that of the Moon from the Earth, that is to say, about 225,000 miles, a satellite revolves round Neptune in a very circular orbit, in 5 days, 21 hours, 8 minutes:* this has enabled astronomers to calculate

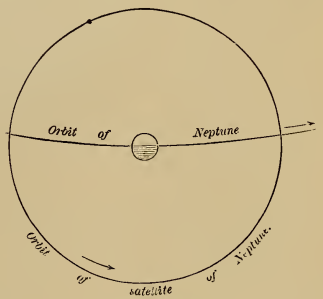


Fig. 48.
SATELLITE OF NEPTUNE.

the mass of the primary. It is equal to about the 1-17000th part of the mass of the Sun, or to 21 times that of the Earth. Hence, the density of the matter of which Neptune consists is less than the fourth of that of the Earth, or nearly equal to the density of nitric acid, and a little less than that of sea-water. From this point of view,

* This disc has not yet presented any perceptible trace of flattening neither can any spot be distinguished on it, so that the time of its rotation remains unknown.

Jupiter is the planet most analogous with this body, whilst the force of gravity at its surface is about the same as on Saturn and Uranus.

Q. Where is the planet Neptune situated?

A. His orbit encircles the entire solar system, being the ninth planet in the order of distance from the Sun.

Q. What is the distance from the Sun?

A. It is 2,850,000,000 miles from the Sun?

Q. What is its diameter?

A. It is thirty-five thousand miles.

Q. How long does it take this planet to perform a revolution around the Sun?

A. It takes one hundred and sixty-six years.

Q. What is its rate of motion?

A. It is eleven thousand miles an hour?

Q. What is the inclination of its orbit to the Ecliptic?

A. It is one degree forty-six minutes and fifty seconds.

Q. What is its time on its axis?

A. Owing to its vast distance, its diurnal motion has not been ascertained.

Q. How many satellites revolve around this planet?

A. Only one has as yet been discovered.

Q. How far from its primary is this satellite situated?

A. It is two hundred and twenty-three thousand miles.

Q. In what time does this satellite revolve around its primary?

A. In five days and twenty-one hours.

Q. What does this indicate?

A. The time of a lunar month on the planet.

LESSON XLV.

ANALYSIS.— Comets — Where found — Appearance — Why called Comets — Appearance Varied — Distinguished from Planets — Form of Orbits — How are they distinguished.

COMETS.

Q. What other planets are found circulating among the planets of the Solar System?

A. They are Comets.

Q. What is their appearance?

A. They are bodies of the nebulous form, composed of a nucleus of a bright center or head; the coma, a kind of envelope of a nebulous substance, and a tail moving in an opposite direction from the Sun.

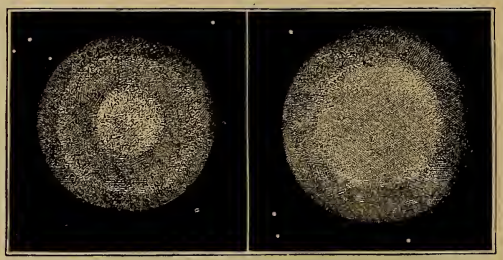


Fig. 49.
1. TAILLESS COMET. 2. HEAD WITHOUT TAIL OR NUCLEUS.

Q. Why called Comets?

A. They derive their name from the Greek word "Come," which means "hair," they resembling it in appearance, hence called Comets.

Q. Is their appearance uniform?

A. They are extremely varied in appearance, some have no tails, others have several tails, some appear without any nucleus.

Q. When these bodies are far away from the Earth and Sun how are they distinguished from the planets?

PLATE XIX.

WEED, PARSONS & CO. ALBANY, N. Y. A. TOLLE, PHOTO-LITH.

FORMS OF COMETS.

A. By the size and position of their orbits and the direction of their motions.

Q. What is the form of their orbits?

A. They move around the Sun either in elliptical orbits or curved lines called parabolus or hyperbolus.

Q. How are they to be distinguished?

A. Those moving in elliptical orbits belong to the Solar System. The others are occasional visitors, coming from far distant regions of space, moving around one side of the Sun, then fly away in paths which continue to diverge, and never return again.

LESSON XLVI.

ANALYSIS.—Elements of Comets — Orbits — Number computed — Classes Elliptic — Long Periods — Shorter Periods — Number Re appeared — They are generally named after their discoverers — Size of Orbits — Comparative inclination of them — Way of Revolution.

ELEMENTS OF A COMET'S ORBIT.

Q. What are the elements of a Comet's orbit?

A. 1st. The longitude of the Perihelion. 2d. The longitude of the Ascending Nodes. 3d. The inclination of the plane of the Ecliptic. 4th. The eccentricity. 5th. The direction of the motion. 6th. The Perihelion distance from the Sun.

Q. The elements of how many Cometary orbits have been computed?

A. More than two hundred and forty, and of that number only nineteen are known to be Elliptic and five hyperbolic.

Q. Into how many classes are Elliptic Comets divided?

A. In two; those of short periods and those of long periods.

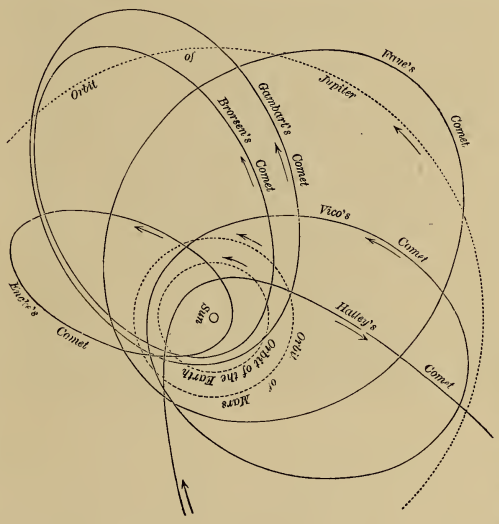


Fig. 50.
ORBITS OF COMETS.

Q. Of these how many have re-appeared?

A. Of the shorter class seven have re-appeared and been identified and established by an entire correspondence of their elements.

Q. Which of these is most distinguished?

A. The Comet Encke; its period has been about three and a-half years, and eighteen returns have been recorded.

Q. What of the others?

A. The period of Dedico's is five and a-half years; Winnecke's five and a-half; Brorsen's five and a-half years; Bielas six and three-fifth years; Donati's six and five-eighth years; Tarje's seven and a-half years.

Q. After whom were these Comets named?

A. After the distinguished Astronomers who discovered them.

Q. What is the comparative size of their orbits?

A. They are small, all revolving within the orbit of Saturn.

Q. What is the comparative inclination of their orbits.

A. They are small, the average being twelve and a-half degrees; the greatest thirty-one, and the least three degrees.

Q. Which way do they revolve?

A. They revolve from west to east.

LESSON XLVII.

ANALYSIS.— Comparative Periods of Comets — Course of Revolution of Comets whose Orbits have been ascertained — One-half of them in opposite directions — Inclinations very diverse — Velocity compared with Planets in general — Far Greater — Number Discovered.

COMPARATIVE PERIODS OF COMETS.

Q. What are the comparative periods of these Comets?

A. With the exception of a few Comets whose periods have been computed to be about seventy-five years, they are considered of very long periods, some more than one hundred thousand years.

Q. Of all the Comets whose orbits have been ascertained, what is the course of the revolution?

A. About one-half are direct, that is, they revolve from west to east, and the remainder are retrograde.

Q. What is said of their inclinations?

A. They are very diverse, some revolve within the zodiac and others at right angles with the Ecliptic.

Q. What is their velocity in comparison to the planets in general?

A. Very much greater. The Comet of 1680 was 880,000 miles an hour, and that of 1843, was 1,260,000 miles an hour, or 350 miles per second.

Q. How many Comets have been discovered?

A. The number is larger, from the earliest period up to the present time more than eight hundred have been recorded, of which three hundred have their orbits computed, and of the latter fifty-four have been identified as returns of previous Comets. Since optical aid has been used in searching for Comets, it is estimated that the actual number of Comets brought to view, including both Hemispheres, is not less than 4,000 to 5,000.

Q. How far from the Sun are they generally discovered?

A. About 1,824,000,000 miles.

Q. Among those Comets which have been noticed, how many passed between the Sun and Mercury?

A. There were thirty.

Q. How many between the other respective orbits?

A. Between Mercury and Venus, forty-four; between Venus and the Earth, thirty-four; between the Earth and Mars, twenty-three; between Mars and Jupiter, six.

LESSON XLVIII.

ANALYSIS.— Celebrated Comets — Comet of 1811 — Dimensions — Aphelion distance — Halley's Comet — How distinguished — Appeared in many previous years — Comet of 1843 — How distinguished — Encke's Comet — Period of Return — What peculiar in its return — Donati's Comet appeared in 1858 — Effect produced — Wonder of Many — For what distinguished — Law by which they are Governed — Description of its Operation — Longitude of the Parhelion of the Comet 1858 — Longitude of its Node — Longitude of the parhelion of the Comet 1862 — Longitude of its Node — Rapidity of Comets — Cause for it.

CELEBRATED COMETS OF THE PRESENT CENTURY.

Q. Among the Comets which have made their appearance during the present century, which are the most distinguished?

A. The one of 1811 is esteemed by Astronomers as a most magnificent Comet.

Q. What were its dimensions?

A. The head was 112,000 miles in diameter; its nucleus was 400 miles.

Q. What was the shape and the length of its tail?

A. Its tail was a beautiful fan-shape, extending not less than 112,000,000 miles.

Q. What is the aphelion distance of this Comet?

A. It is fourteen times that of Neptune, or 40,000,000,000 miles, reaching far beyond the Solar System or the stretch of the largest telescope.

Fig. 51.
GREAT COMET OF 1811, FROM A DRAWING BY ADMIRAL SMYTH, IN THE "SPECULUM HARTWELLIANUM."

Q. What is said of the Comet of 1835, commonly known as Halley's Comet?

A. This is remarkable as being the first Comet whose period of revolution was satisfactorily established.

Q. What led Dr. Halley to suspect that this was the reappearing of a former Comet?

A. He on examining the great Comets of 1531, 1607, and 1682, believed they were only the reappearance of the same Comet.

Q. What period did he fix as the time in which it uniformly returned?

A. He established the time of the interval at seventy-five years.

Q. How has he convinced the world that he was correct in his conclusions?

A. He declared that the Comet would again make its appearance in the last of 1758, or in the beginning of 1759.

Q. What was the result of his prophecy?

A. Great interest was felt, and though he died before the time, yet on Christmas night, 1758, a peasant near Dresden discovered the Comet.

Q. In looking back upon past history, have we reason to believe that this Comet had made its appearance at similar intervals before the days of Halley?

A. It was seen in England in 1066, when it was regarded as the forerunner of the victory of William of Normandy.

Q. What then was its appearance?

A. It was then in size equal to the full Moon, and in 1456 its tail reached from the Horizon to the Zenith. Pope Calixtus indited a prayer for the people as follows: "Lord save us from the Devil, the Turk, and the Comet."

Q. What is regarded the earliest record given of this Comet?

A. In the 130th year before Christ.

Q. What was said of its light?

A. That its light surpassed the brilliancy of the Sun.

Q. For what was the Comet of 1843 distinguished?

A. It was so intensely brilliant as to be visible in full daylight; and it was so near the Sun as almost to graze his surface.

Q. What period is designated as the time of the return of Encke's Comet?

A. Its period is only three and a half years.

Q. What interesting discovery has been made from observations upon its motion?

A. It returns invariably to its perihelion, two and a half hours earlier than the most perfect calculations indicate.

Donati's Comet.

Q. What is said of Donati's Comet which appeared in 1858?

It produced great excitement and was the cause of universal wonder.

Q. What was its distance from the Earth when first discovered?

A. In June of that year it was 240,000,000 miles and in August traces of its tail were observed which extended to about 50,000,000 miles in length.

Q. For what other manifestations has this Comet been distinguished?

A. It has never been excelled for the brilliancy of its nucleus and the graceful curvature of the tail.

Q. When will it return?

A. In about 2,000 years.

Q. What great law controls the motion of the Comets?

A. They are controlled by the same specific law which governs Planets of the Solar System. When in their orbits thousands of millions miles from the Sun, they move very slow in the arc of an ellipse, almost immeasurable, having lost their charge of Coloric, they become minus. The Sun being positive and they deeply negative, it begins to exert a controlling influence over them, as that attraction increases continually in proportion as the squares of the distance decrease, they move swifter and swifter until, as they approach the Sun, they sometimes fly more than eight hundred thousand miles an hour. At their Perihelion they are very near the Sun and become very highly positive, and hence are propelled back again into fields of space with the same lightning speed that they were attracted toward the great Fount of all motion.

Q. What is the longitude of the Perihelion of the Comet of 1858?

A. It is thirty-six degrees and thirteen minutes.

Q. What is the longitude of its Node?

A. It is one hundred and sixty-five degrees and nineteen minutes.

Q. What is the inclination of its Angle?

A. Sixty-three degrees and two minutes.

Q. What is the longitude of the Perihelion of the Comet of 1862?

A. It is forty-nine degrees and seven minutes.

Q. What is the longitude of its Node?

A. It is two hundred and seventy-eight degrees and fifty-eight minutes.

Q. What is the inclination of its orbit with the plane of the Ecliptic?

A. It is fifty-eight degrees and twenty-nine minutes.

Fig. 52.

COMET OF 1744 (CHESEAUX'S COMET), WITH MULTIPLE TAILS.

It is right to say that among the numerous comets observed up to the present time, either with the naked eye, or by means of telescopes, the majority are distinguished by a nebulosity surrounding the nucleus, and a great number, especially of the most brilliant ones, possess a luminous train or tail. With others, the tail, displayed fan-like, is divided into many branches, as if the body had in reality several distinct tails. Fig. 52 gives an idea of the varied forms of these cometary appendages.

This diversity of aspect will, perhaps, some day, enable astronomers to class comets into genera, species and varieties, and will doubtless facilitate the perfection of the theory of the phenomena which these bodies present, which is still so obscure.

Comets, as we have said, form part of our Solar System. Like the planets, they revolve round the Sun, traversing with very variable velocities extremely elongated orbits; the form of the cometary orbits furnishes us with the first of their specific characters. *

Q. Why do Comets pass out of sight so rapidly after passing their Perihelion?

A. They move around the Sun in orbits much more elongated than that of the Earth and when they cross the plane of the orbit of the Earth on their flight to regions of space, they are then moving in one direction and the Earth in another, and as the Earth moves at the rate of sixty-eight thousand miles an hour and the Comets at the rate of a million miles an hour, they seem to move much faster as they soon disappear, while their motion is slower and slower till they arrive at their Aphelion point.

Q. What may be considered a remarkable fact in respect to Comets?

A. That the real diameter of their nebulosity increases proportionally as they become more distant from the Sun, and the nearer they come, the smaller the nucleus but the more brilliant.

Q. What forms the ground work of all our calculations respecting the distances of all celestial orbs?

A. The semi-diameter of the Earth.

Q. What is necessary or sufficient to enable a person to understand the mode by which the distances of the heavenly bodies are determined?

A. A slight knowledge of Geometry and Trigonometry.

* NOTE. As we go to press, a new Comet is announced, discovered first at Marseilles, France, April 17, by Mons. Coggia, and recently detected by Prof. Swift of Rochester, N. Y. Although its direction is represented as earth-ward, yet no fears are entertained of a collision, for the electrical law of radiation is sufficient to prevent it. Reference as to location, may be had to Map 1 of the Star Sketches in this Atlas, page 75.

LESSON XLIX.

ANALYSIS. — What supposed to be — How produced — What called — Why so called — How many seen in an Hour — Showers of Stars — When exhibited — At what Intervals — Hombold and Bompland's Observations — Arago's Observations — Regular Periods of Showers — Intersection of the Earth and the Orbit of the Comet — Brilliant display accounted for — Light produced by their rapid flight through the Atmosphere — Annual Exhibition of Meteors in August — Regularity accounted for — Schiaparelli's discovery.

METEORS, SHOOTING STARS OR AEROLITES.

In the immense number of meteors which invade the regions of the air in a year, there are some perhaps that only pass through its domain and continue their path in space, after having presented us with the spectacle of a transient illumination. A great number, on the other hand, not only do not again leave our atmosphere, being vaporised therein, but, when of large size, attain the very surface of the Earth. Falls of stones, ferruginous masses, and dust, from the upper regions of the air, are proofs of this assertion.

From shooting stars to meteors, or *bolides*, the transition in our narrative is easy: the difference between these two orders of phenomena is not very strongly marked.

Bolides are luminous bodies of circular, or rather of spherical, form, and of sensible apparent diameter. Like shooting stars, they appear suddenly, but generally they move more slowly, and disappear after some seconds. Their light is ordinarily less vivid, but their much more considerable apparent dimensions are sufficient to compensate this difference of intensity. The illumination of the landscape by the presence of a meteor sometimes approaches that of moonlight. Most of them leave behind a luminous train; others explode with violence, and sometimes the explosion is accompanied with reports like discharges of artillery.

The appearance of meteors is more rare than that of shooting stars, the total number of observations recorded amounting at most to a thousand, reckoning those recorded by the ancients.

A curious circumstance, and one which helps to prove the relationship between the shooting stars and meteors, is the fact that the appearances of meteors are more frequent in August and November than at other epochs of the year; and the total number from July to December exceeds also that observed from December to July.

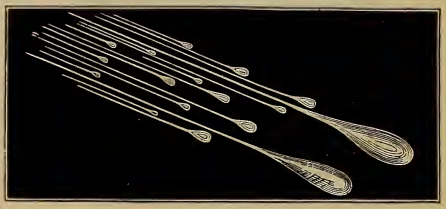


Fig. 53.
APPEARANCE OF A METEOR IN A TELESCOPE. (SCHMIDT.)

[One of the most curious observations of a meteor which have been recorded, leaving that of 1783 out of the question, was recently made by Dr. Schmidt, who was fortunate enough to observe a large meteor in a telescope, under a magnifving power of eight times. The fire-ball was twin, and was followed by several smaller ones, following side by side with parallel motions of translation until all were extinguished (fig. 53). This observation lends force to the supposition that meteors exist in space as a crowd of bodies, revolving round each other, before they enter our atmosphere.]

Q. What are they supposed to be, and how are they produced?

A. Of metallic substances similar in composition to the Comets themselves accompanying them in their revolutions around the Sun, as cosmical clouds or meteoric swarms.

Q. Why called Shooting or Falling Stars?

A. Because of their rapid motion in darting through the heavens.

Q. How many may be observed in ordinary times in the interval of an hour?

A. From ten to twenty may be seen.

Q. At what periods of time does the shower of Stars exhibited on the 12th and 13th of November occur?

A. At intervals of thirty-three years.

Q. What evidence have we of this phenomenon?

A. Homboldt and Bompland observed on the 12th and 13th of November, 1799, a shower of Stars, as a real rain of fire.

Q. In what following year did it recur in great force?

A. In the year 1833, November 12th, Arago compared the shower to a fall of snow.

Q. When did the last periodic shower occur?

A. It was again observed on the 14th of November, 1867.

Q. How is the regularity of these seasons accounted for or determined?

A. On the principle of the regularity of the revolution of the Earth, and the intersection of its orbit by the passage of the meteoric shower when the Earth is passing through the cloud or very near it at the time of the periods above mentioned.

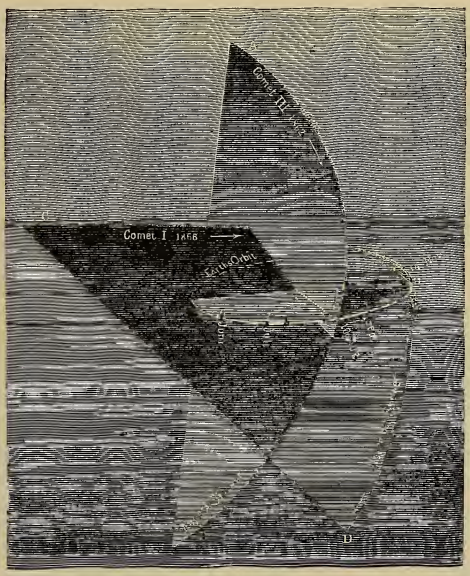


Fig. 54.

ORBITS OF THE AUGUST AND NOVEMBER METEOR-SHOWERS. (ORBITS OF COMETS III., 1862, and I., 1866.)

Q. How can you account for the brilliant display of light exhibited in their passing through the heavens?

A. Their light seems to be produced by their rapid flight through the atmosphere, causing their ignition by the compression of the air and their consumption in their passage.

Q. What are we to understand respecting the meteors annually exhibited on the 10th of August?

A. The August Meteors annually revealed to us are produced by their annual revolution intersecting the Earth's orbit on the 10th of August.

Q. What reason have we to conclude that this ring of meteoric stones represents the orbit of a previous Comet?

A. Schiaparelli has in fact discovered so close a resemblance between the path of the August meteors and that of the Comet 1862, No. 3, that there cannot be any doubt as to their complete identity.

The calculations of Schiaparelli, Oppolzer, Peters, and Le Verrier, have also discovered the comet producing the meteors of the November shower, and have found it in the small comet of 1866, No. I., first observed by Tempel, of Marseilles. Its transformation into a ring of meteors has not proceeded nearly so far as that of the

comet of 1862, No. III. Its existence is of a much more recent date; and, therefore, the dispersion of the meteoric particles along the orbit, and the consequent formation of the ring, is but slightly developed.

According to Le Verrier, a cosmical nebulous cloud entered our system in January, A. D. 126, and passed so near the planet Uranus as to be brought by its attraction into an elliptic orbit round the Sun. This orbit is the same as that of the comet discovered by Tempel, and calculated by Oppolzer, and is identical with that in which the November group of meteors make their revolution.

Since that time, this cosmical cloud, in the form of a comet, has completed fifty-two revolutions round the sun, without its existence being otherwise made known than by the loss of an immense number of its components, in the form of shooting-stars, as it crossed the Earth's path in each revolution, or in the month of November, in every 33 years. It was only in its last revolution, in the year 1866, that this meteoric cloud, now forming part of our solar system, was first seen as a comet.

The orbit of this comet is much smaller than that of the August meteors, extending at the aphelion as far as the orbit of Uranus, while the perihelion is nearly as far from the Sun as our Earth. The comet completes its revolution in about 33 years and 3 months, and encounters the Earth's orbit as it is approaching the Sun toward the end of September. It is followed by a large group of small meteoric bodies, which form a very broad and long tail, through which the Earth passes on the 13th of November. Those particles which come in contact with the Earth, or approach so near as to be attracted into its atmosphere, become ignited, and appear as falling stars. As the Earth encounters the comet's tail, or meteoric shower, for three successive years at the same place, we must conclude the comet's track to have the enormous length of 1,772,000,000 miles. In Fig. 54, C D represents a portion of the orbit of this comet which is identical with the orbit of the November meteors. — *Spectrum Analysis.*

LESSON L.

ANALYSIS. — Remarks — Constellations — Design in presenting an *Elementary* Work — Not Extensive or Critical — In considering the Stellar Universe — The Object in Presenting Constellations — How differ from Planets — In Twinkling and Scintillating — Description of a few — Exhibited in the Northern Sky — The best time of observing them — What Called — Why Called Northern Circumpolar — North Pole point of Revolution — Consideration of Maps — MAP I. — Constellation *Great Bear, Ursa Major* — Time of appearance — Number of Stars contained in the Group — Figure formed Large Dipper — Two Northern Stars Pointers — Why called thus — Polaris the object to which they point — Revolution — 2d Constellation — *Little Bear* — How Distinguished — Contains Polaris — North Pole Star — A *Fixed Star* — Why called Fixed Stars — They revolve in the Universe — Great Velocity — Time its Light travels down to us — 3d Constellation — *Cassiopia* — Location — Form of Figure — Sprawling "W" — Cepheus and Draco — Where Located — Nothing Striking — Perceus elsewhere.

CONSTELLATIONS.

Remarks. — It is not my design in this *Elementary* Work to be very extensive or critical in what may be presented of the Stellar Universe.

In studying the stars, that we may the more easily comprehend their location in the heavens, they have been arranged in groups, called *Constellations.*

We will now present some of these Constellations, and describe a few of the principal stars contained in them, as exhibited in our northern sky, with the best time for looking at them.

Q. How do they differ in appearance from the planets?

A. They twinkle or scintillate, and no telescope has been able to enlarge them into a disc.

Q. What are these constellations called?

A. They are called Northern Circumpolar and Southern Constellations.

Q. Why called Northern Circumpolar?

A. Because they revolve around the north polar star, recognized on map I, as Polaris.

Q. In considering the following *Star Maps*, how are their points of the compass arranged.

A. The right hand west, the left hand east, the top of map north and the bottom south.

MAP I.

Constellation The Great Bear. — Ursa Major.

Q. What time of the year are the constellations on this map most clearly revealed?

A. About the first of November, at nine o'clock in the evening, in our latitude, they are visible every night.

Q. How many stars in this constellation are visible to the naked eye?

A. There are one hundred and thirty-eight.

Q. How are the seven principal stars arranged?

A. They appear in the form of a Large Dipper.

Q. What are the two extreme northern stars in the cup called?

A. They are called pointers.

Q. Why are they so called?

A. Because they point out and are always in range with a bright star called Polaris.

Q. How often does the dipper revolve around this star?

A. Once in twenty-four hours, never sinking below the horizon.

Q. What other constellations are revealed on this map?

A. Little Bear and Cassiopia.

Little Bear, or Ursa Minor.

Q. For what is this constellation distinguished?

A. Its form is that of a little dipper, containing seven stars, one of them distinguished as the Pole Star, called Polaris.

Q. Why called the Pole Star?

A. It is esteemed the point of the northern pole of the Earth.

MAP I.

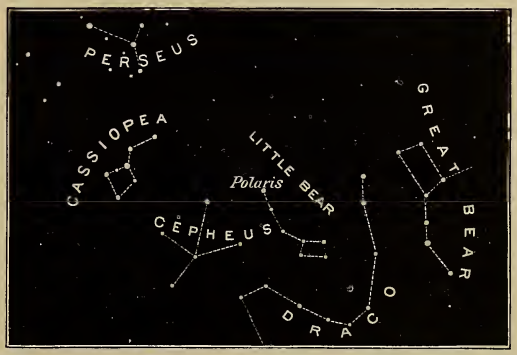


Fig. 55.

Q. To what important class of stars does Polaris belong?

A. To those called *Fixed Stars* or *Suns*.

Q. Why are they called Fixed Stars or Suns?

A. Because they have appeared for ages to occupy the same place.

Q. Do they not revolve in their orbits like the planets?

A. Their rate of motion is far greater than that of many of the planets.

Q. What is the rate of motion of Polaris?

A. It is ninety miles per minute.

Q. How long does it take its light to reach the Earth?

A. It takes fifty years.

Q. How many stars are visible in this constellation?

A. There are twenty-seven.

CONSTELLATION — CASSIOPIA.

Q. Where is this constellation located on the map?

A. Nearly east of Polaris.

Q. What is the form in which the principal stars are grouped.

A. They are arranged somewhat like a broken-backed chair, or a sprawling capital W.

Q. What other constellations are found on this map?

A. Cepheus and Draco are located nearly south of Polaris.

Q. Is there any thing striking in their features?

A. There is nothing, and Perseus is better represented on another map.

LESSON LI.

CONSTELLATION ORION.

ANALYSIS. — MAP II —Time of favorable appearance — Names of the Constellations — Distinguished — The most beautiful Constellation in the Sky — Whale better seen elsewhere — Stars of Belt of Orion—The Bull or Taurus — Situation —How Marked — Cluster called Hyades — Another cluster called Pleiades — Another Constellation called Gemini, or the Twins — Where Situated —Names of the most important Stars — Castor and Pollux — Little Dog — Location — How distinguished — Procyon and Gomelza — Great Dog — Situation —Name of the largest — Sirius Brightest Star — Rate of Motion — Time it takes to reach the Earth —Distance estimated — Diameter — Constellation The Whale — Situation.

MAP II.

Q. What time of year may the constellations on this map be most easily pointed out?

A. About the first of February, at nine o'clock in the evening.

Q. What are the names of the constellations on this map?

A. Orion, Bull, Twins, Great Dog, Little Dog, and the Whale.

Q. For what is Orion distinguished?

A. It is the most beautiful constellation in the sky.

Q. How many stars form the belt of Orion and where are they located?

A. There are three stars in a line, near the center of the parallelogram, called the belt of Orion.

MAP II.

Fig. 56.

BULL, OR TAURUS.

Q. Where is the group called the Bull, situated?

A. It is in the north-west, and marked by a V shaped cluster, called Hyades.

Q. What cluster of stars is found near it?

A. A group of seven stars may be found north-west of Bull, called Pleiades.

Q. Where can the constellation Geminii or the Twins be found?

A. North-east of Orion, at this time.

Q. How is it marked, or what is its shape?

A. It is marked by a large quadrilateral of stars.

Q. What are the names of the most important stars in this group?

A. They are Castor and Pollux, the most northern and brightest stars of the group.

Little Dog.

Q. Where is the location of the Little Dog?

A. It is situated east of Orion.

Q. How is it distinguished?

A. It is marked by two solitary stars, Procyon and Gomelza.

The Great Dog.

Q. How is this constellation marked and where located?

A. It is a group of several stars, located south-east of Orion.

Q. What is the name of the largest star and for what is it distinguished?

A. It is called Sirius, and is the largest star in the whole heavens.

Sirius.

Q. What is the rate of motion of Sirius?

A. It is eight hundred and forty miles per minute.

Q. How long does it take the light to reach the Earth?

A. It takes twenty-two years.

Q. What is its estimated distance from the Earth?

A. It is said to be 3,375,000 times that of the Sun from us.

Q. What is its diameter?

Q. Twelve millions miles in diameter.

The Whale.

Q. Where is he situated?

A. He is located north-west of Orion.

LESSON LII.

Constellation Virgo.

Analysis. — MAP III — Favorable time for Inspection — When seen in the Heavens — How known — Large Constellation — One Star of first Magnitude — Spica its name — Leo, or the Lion — Where situated — How easily known — Shaped like a Sickle — An inverted figure 5 — Regulus the largest — On the Ecliptic — Gamma — Where situated — 3d Constellation — Hydra — Situation — Form of Serpent Swimming from East to West — Stars small.

MAP III.

Virgo.

Q. At what time is this constellation more clearly seen?

A. On the first of April, at nine o'clock in the evening.

Q. Where in the heavens may it be seen at this time?

A. Near the Meridian.

Q. How may it be known?

Fig. 57.

A. It is a large constellation, with one star of the *first* magnitude, called Spica; the others are not easily traced without a Plenisphere.

Leo, or the Lion.

Q. Where situated?

A. Just west of Virgo.

Q. How is it easily recognized?

A. By six stars,

shaped like a sickle or an inverted figure 5.

Q. Which of these stars is the brightest, and where situated?

A. It is a star called Regulus, and is on the Ecliptic.

Q. What is the next important star in this group and where located?

A. It is Gamma, and is generally situated near the radient point of the November meteoric shower.

Constellation Hydra.

Q. Where situated?

A. It is located south of Leo and Virgo.

Q. What is its form, course and size of the stars?

A. It is the form of a serpent, swimming from east to west, and its stars are small.

LESSON LIII.

Constellation Bootes.

Analysis. — MAP IV — Time of Appearance — In June — Situation in the Heavens — The Brightest Star Arcturus — Where found — On Meridian — Shape Parallelogram — Four bright Stars — Form — Coffin — Another group East — Like a boy's cap — Northern Crown — Large Constellation further East — Hercules — Size — What figure — Two Quadrilaterals — Opinion respecting the course of the Solar System — Drifting toward Hercules.

MAP IV.

Constellation Bootes.

Q. What is the time of its appearance?

A. In the month of June, nine o'clock, P. M.

Q. Where in the heavens may this constellation be found at this time?

A. It may be seen on the meridian, south-east of the Great Bear.

Q. What is the name of its largest star?

A. It is called Arcturus.

Q. Where in the heavens may it be found at this time?

A. Facing the south, you will see it on the meridian, and in shape like a parallelogram, of four bright stars.

MAP IV.

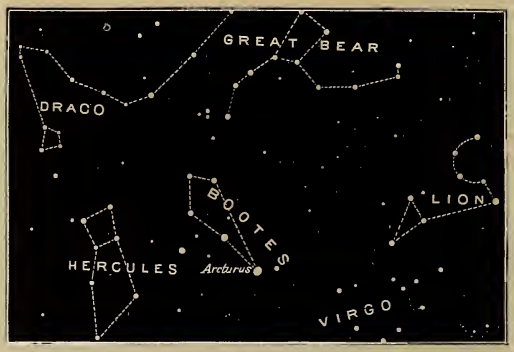


Fig. 58.

Q. What form does this group of stars represent?

A. They form a figure somewhat similar to a coffin.

Q. What group of stars is found east of Bootes?

A. A semi-circle of stars, like a boy's cap, called the Northern Crown.

Q. What large constellation may be found further east?

A. It is called Hercules.

Q. What is the size of the stars and what figure do they form?

A. They are small and present the figure of two quadrilaterals.

Q. What is the present opinion entertained as to the course the Solar System is now taking?

A. It is supposed to be drifting toward Hercules.

LESSON LIV.

Constellation The Swan.

Analysis. — MAP V — Time favorable — Where found — Overhead — Figure formed — Large Cross — Principal Star at foot — Albireo — Multiple Star — The Eagle — Where situated — South of Swan — How distinguished — A Large Star — Atair — Pegasus — Where located — North-east of Eagle — Figure of these Stars — Perfect Square — The most Western found — Head of Andromedia — The Lyra — Where situated — West of Swan and North-west of Eagle — What Star Prominent — Vega — What completes the group — Four faint Stars.

MAP V.

Constellation The Swan.

Q. What time in the year does this constellation make its appearance?

A. On the first of September, 9 o'clock in the evening.

Q. Where can the Swan be found at this time?

A. Overhead, in the Milky Way.

Q. What is the figure formed by the stars of this constellation.

A. They are so arranged as to form a large cross.

Q. What is the name of the principal star at the foot?

A. It is called Albireo, a multiple star.

MAP V.

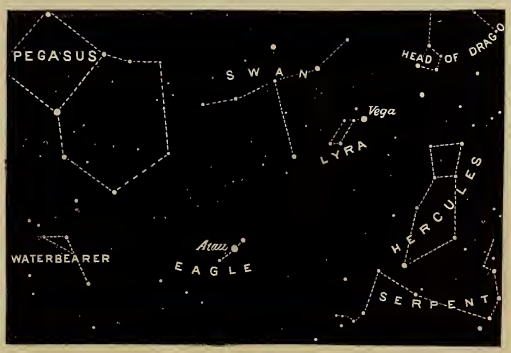


Fig. 59.

The Eagle.

Q. Where is it situated?

A. Nearly south from the Swan.

Q. How is this constellation distinguished?

A. It is marked by a very large star called Atair, and several small ones.

Pegasus.

Q. Which way from the Swan is this group located?

A. It is situated directly east of the Swan, and north-east of the Eagle.

Q. What is the figure represented by these stars?

A. A perfect square is formed by four of the principal stars.

Q. Where is the most western one found?

A. It is located in the head of Andromedia.

The Lyra.

Q. Where is this constellation situated?

A. It is found located west of the Swan, and north-west of the Eagle.

Q. What distinguished star is found in this constellation?

A. There is a very bright star called Vega.

Q. What other stars complete the group?

A. Just below Vega are four faint stars, forming an oblique parallelogram.

LESSON LV.

Constellation Perseus.

Analysis.—MAP VI—When favorably seen—December—Where found—Meridian—Well North in Milky Way—Figure of chief Star—Turkish Sword—Bent at the point—What near the point—Mass of Telescopic Stars, very beautiful—One marked—Called Algol—*Constellation Aries or Ram*—Where seen—South of Perseus—Figure formed of Principal Star—Right-Angled Triangle—Point in the Seasons marked—Vernal Equinox—What Constellation South of the Ram—Whale—Figure easily traced—Pentigon of Stars.

MAP VI.

Constellation Perseus.

Q. What time is most favorable for its exhibition?

A. In the month of December, 9 o'clock P. M.

Q. Where then can it be found?

A. On the meridian, well to the north, in the Milky Way.

Q. What is said of the chief stars in this constellation?

A. They are not very bright, but they form the figure of a Turkish sword, much bent at the point.

Q. What is discovered near the point of the sword?

A. There is a mass of telescopic stars, the most beautiful, perhaps, in the sky.

Q. What one is found near this group which is rather a marked star.

A. It is called Algol, distinguished as a strange, variable star.

MAP VI

Fig. 60

Constellation Aries, or The Ram.

Q. Where is this seen?

A. It is discovered south of Perseus.

Q. What kind of a figure is formed by the principal stars?

A. It forms a right-angled triangle.

Q. What point in the Seasons is marked by this constellation?

A. Long ago it has been known to mark the place of the Vernal Equinox.

Q. What very large yet indistinct constellation is found south of the Ram?

A. It is the Whale.

Q. What figure is easily traced in it?

A. There is clearly seen one pentigon of stars.

LESSON LVI.

Contrast of the Distance of the Sun and that of the *Fixed Stars* From the Earth.

Analysis.— Remarks.— Rate of motion of ball from an Armstrong gun — Time taken to reach the Sun — Time for the sound of the Explosion to reach the Sun — Prof. Mendenhall on nervous sensation — The infant burns its finger by touching the Sun — Time necessary to realizing the sensation — Earth on disc of Sun — Require a large telescope to discover it — Distance of Sun from Earth compared to that of the *Fixed Stars* — The Fixed Stars, Suns — Do not remain unmoved — Revolve in the *Universe* like other Planets — Principal Suns named — Why appear small — Distance cannot be computed by miles — Velocity of light considered — Miles per second — Number in 24 hours — At this rate how long to reach the nearest *Fixed Star* — 61 *Cygni* — *Vega* — *Sirius* — *Ursæ Majoris* — *Arcturus* — *Polaris and Cappella* — These do not shine by reflection — Suns in other Systems.

On the Distance of the Sun.

Remark. — Reflection only can bring to our minds an adequate idea of the immense distance which exists between us and the Sun.

Q. What is the rate of motion of a ball fired from an Armstrong gun?

A. It is four hundred yards per second.

Q. At this rate, how long will it take for it to reach the Sun?

A. It will take thirteen years.

Q. How much longer before the sound of the explosion would reach the Sun?

A. Six months later.

Q. Which travels the faster, sound or nervous sensation?

A. Prof. Mendenhall says, sensation upon the nerves travels ten times slower than sound.

Q. If, therefore, an infant were born, with an arm of the somewhat inconvenient length of 91,500,000 miles, so as to reach the Sun, and should he stretch out his arm, touch the Sun, and burn his finger, how long before he would feel the sensation?

A. That child must live till it has grown to manhood, and reaches the age of 135 years, before he will be conscious of the fact that the tip of his finger was burned.

Q. Suppose the Earth be placed on the disc of the Sun, could it be seen with the naked eye?

A. It would require the aid of a large telescope to make it visible.

Q. With all this disparity of the size and distance of the Sun from the Earth, how much greater the size and distance from the Earth is one, even the nearest of what are termed Fixed Stars?

A. We can only answer this question by comparison — hence, call your attention to the following in respect to what is said of the Fixed Stars.

Fixed Stars.

Q. What are they?

A. They are called Suns.

Q. Why Fixed Stars?

A. They appear always to occupy the same place in the heavens.

Q. Do they remain unmoved as Fixed Stars?

A. They revolve in their respective orbits in the Universe, like other planets.

Q. Can you name the principal Fixed Stars?

A. Alpha Centauri, 61 Cygni, Vega, Sirius, Ursæ Majoris, Arcturus, Polaris, Capella.

Q. Why are they so small?

A. They are so far from us.

Q. How far off is the nearest?

A. So far it is impossible to compute its distance by miles.

Q. How can we obtain an adequate idea of its distance from the Earth?

A. Something of an idea may be gained of the distance if we consider the rapidity with which light travels.

Q. What then is the velocity of light?

A. It is one hundred and ninety-two thousand miles per second.

Q. How many seconds are contained in twenty-four hours?

A. Eighty-six thousand and four hundred.

Q. According to this basis of reckoning, how far will light travel in twenty-four hours?

A. It will traverse sixteen billions five hundred and eighty-eight millions eight hundred thousand miles.

Q. At this rate, how many days will it take the light of the nearest fixed star to reach us?

A. It must continue its course at this tremendous velocity thirteen hundred days, or over three and a-half years, before a glimpse of it can be obtained by any of the inhabitants of the Earth.

Q. If this incomprehensible distance lies between us and the nearest Fixed Star, what must be that lying between the Earth and the most distant?

A. In answer, we will give the number of years required by light to travel the different distances of other fixed stars:

1. Alpha Centauri, three years and six months.
2. 61 Cygni, nine years and four months.
3. Vega, twenty-one years.
4. Sirius, twenty-two years.
5. Ursæ Majoris, twenty-two years.
6. Arcturus, twenty-six years.
7. Capella, seventy-two years, or 390,541,824,000,000 miles.

Polaris.

8. Polaris, fifty years, or 271,209,600,000,000 miles.

Q. What is the rate of motion of Polaris?

A. It is ninety miles per minute.

Q. How long does it take its light to reach the earth?

A. It takes fifty years to travel down to us.

Q. Do you perceive the utter impossibility that these stars shine by reflected light?

A. It is evident that they are Suns — each of them is a focus of light and heat, and probably the center of a system comprising, like ours, planets, satellites and comets.

LESSON LVII.

Light.

Analysis.—What is it —Views of Sir Isaac Newton — Flowing out from the "*Orb of Day*"— Recuperation, or Waste Away — Space embraced in Solar System — Rapidity of light —At this rate how long will it take to fill the Space — Does not remain Stationary — Moves on in Circle — Light changes its Polarity — Is received back to the Sun — How does the Sun remain undiminished and brilliant as ever — By recuperation in the return of it to the Sun — No indication of a continued work of creation — Principle illustrated by.

Q. What is light?

A. It is an electrical effusion of brilliant particles or bright scintillations emanating from the Sun.

Q. What was the theory of Sir Isaac Newton respecting the origin of light?

A. That light is an emanation of inconceivably minute particles flying off from the body of the Sun through that space which is occupied by those opaque bodies which are governed by its influence.

Q. If light be an emanation of infinitesimal atoms, or particles of matter flowing out from the "Orb of day," why is it not diminished and wasted away?

A. This could not fail to be manifest if there was not a constant recuperation or increase of the original fountain.

Q. To what extent does light emanate from the Sun?

A. It is an acknowledged and well-authenticated fact in science, that light radiates in every direction from this central luminary, filling the entire space occupied by the Solar System.

Q. How many miles of space are embraced in the Solar System?

A. Not less than seventeen billions one.hundred million miles.

Q. What is the velocity of light?

A. Light travels at the rate of one hundred and ninety-two thousand miles in a second.

Q. At this rate, how long will it take to fill the vast and almost infinite space described above, with light?

A. It will take about four hours.

Q. When this vast expanse is once filled with this ocean of light, does it continue to occupy this immense space?

A. Overflowing light is one of the forms in which the element of the Sun, electricity, is manifested throughout the Solar System.

Q. What peculiar course does electricity pursue when it flows out from the Sun?

A. Electricity always runs in a circle, hence returns to its original fountain.

Q. What conclusion must necessarily be drawn in respect to the course taken by light?

A. That light being an exhibition of one of the forms of electricity, it must in like manner flow in a circle, and again return to the place whence it emanated.

Q. Do you ask how light can return to the Sun?

A. It was thrown out by the *positive* force of the Sun, and having changed its polarity it is attracted and received back to the Sun.

Q. Are we then to understand that the great ocean of light, filling the entire Solar System, passes on and gives place to another?

A. On this principle the vast ocean of light must give place and the space be filled by another, every four hours, then displaced and filled again in the same short space of time, and so on, in endless succession.

Q. What must have been the inevitable result, if light be the emanation of infinitesimal effusions from the Sun, unsupplied from some source?

A. The Sun long since would have frittered away and been utterly annihilated by waste.

Q. How then has it remained undiminished and as brilliant as ever?

A. Evidently this waste must be supplied either by the return, in some imperceptible manner, of these particles to their original source, or that the Sun, the great fountain of light, be constantly fed by creative agency exerted upon it.

Q. If the latter conclusion be entertained, what principle in the order of creation would be violated?

A. From the order of creation we learn that all things were created in a limited time, hence, no indication is given of a continued work of creation.

Q. What may be regarded the most reliable and correct position to be occupied in this matter?

A. We are, from full evidence, inclined to the former position, and in sustaining it, present the fact that light is only the ever-flowing scintillations of electricity, and, like it, necessarily runs in a circle; hence, having accomplished its mission, returns, like all electrical currents, to its original fountain, the Sun.

Q. What beautifully illustrates this principle of action?

A. The ocean, by evaporation, supplies the clouds with water, this is borne over the globe, and discharged among the mountainous regions to

supply the high lakes and fountains, these, in return, send forth the little rills and streams, which, meeting in their course, form rivers, which empty into the ocean again, and keep that immense reservoir from becoming exhausted.

LESSON LVIII.

Attraction of Gravitation.

Analysis.— Attraction of Gravitation defined — Seen in the power the Sun exerts over the Planets — All under the magnetic influence of the Sun — Planets rendered Magnets by the electrical power of the Sun — This inherent magnetism controls the Satellites — This magnetism called Terrestrial Magnetism — Subject *Terrestrial Magnetism* or the *Magnetism of the Earth* — This magnetism accounted for — Sun a great Galvanic Reservoir — Heat of Torrid Zone — Compared with Temperate and Frigid Zone — Intensity of the heat of the Sun — Three hundred times greater than any point on the Earth's surface — Sir John Herschell's estimate — Note.

Q. What is the attraction of gravitation?

A. It is the magnetic influence which one body has over another in attracting it to itself.

Q. How is this manifest in the planetary system?

A. It is seen in the power exerted by the Sun over the planets, and in the controlling power of these over their satellites.

Q. How do the planets receive their magnetic influence?

A. They receive it from the Sun.

Q. Are all bodies, more or less, under the influence of magnetism?

A. All the heavenly bodies in the Solar System are more or less under the influence of this magic power.

Q. How do they receive their magnetic influence from the Sun?

A. The Sun is a great Galvanic Battery, and, by its electrical power, renders the Earth and every planet a magnet.

Q. What is the influence these planets exert upon their satellites and other bodies surrounding them?

A. This inherent magnetism of the planet controls its satellites and every thing else within the scope of its influence.

Q. What is this magnetism called which is manifest in the Earth?

A. It is called terrestrial magnetism.

Terrestrial Magnetism, or the Magnetism of the Earth.

Q. How is terrestrial magnetism accounted for?

A. Upon the theory that the Sun, being the great Galvanic reservoir, pours its streams of light and heat vertically upon the space embracing forty-seven degrees of the Earth's middle regions, or twenty-three and a-half degrees each side of the equator, constituting the torrid zone.

Q. What is the heat of the torrid zone when compared with the temperate or frigid zones?

A. Far greater, and always uniform and excessive.

Q. What is supposed to be the intensity of the heat at the surface of the Sun?

A. It has been estimated to be three hundred times that received at any point of the Earth's surface.

Q. What estimate did Sir John Herschell place upon the heat of the Sun?

A. He supposed that it would be sufficient to melt a cylinder of ice forty-five miles in diameter, plunged into the Sun, at the rate of two hundred thousand miles a second.

Note. — This estimate being correct, we are not surprised that the entire planetary system is under the electrical control of this great Galvanic Battery, and, as a consequence, revolve in their respective spheres, accomplishing the will of their Creator.

LESSON LIX.

Terrestrial Magnetism — Continued.

Analysis.— Torrid regions — More deeply electrified — Result — They are positive — Polar negative — Reasons for this — Effect produced upon the Earth — Earth filled with electricity becomes a *magnet* — This Terrestrial Magnetism seeks and flows out of the Magnetic Poles — Points of the greatest cold — Both North and South — Result — Consequence of the combined action of these forces — Explanation — Effect of these currents on the Needle — Magnetic Poles and Geographic not the same — At the Geographic no effect on the needle — Reasons why — Note.

Q. What is the consequence of those torrid regions being more directly under the influence of the Sun's rays?

A. Those regions become more deeply electrified than either the temperate or frigid zone.

Q. What other results necessarily follow?

A. The equatorial regions are positive, while the polar regions are comparatively negative.

Q. What reasons can be given for this?

A. The first reason is, that the forty-seven degrees, or the 3,266½ statute miles of the Earth's surface, embraced between the 23½ degrees of north and 23½ degrees of south latitude, constitute the bulkiest part of the globe, under the powerful rays of the Sun.

Q. This being the case, what effect is produced upon the Earth?

A. The torrid regions receive the greatest amount of electricity, and, through them, the Earth is filled with it, and becomes a magnet.

Q. At what points of the Earth's surface does its internal magnetism naturally radiate and flow out?

A. From the negative portions of the Earth, especially through the magnetic poles — the points of the greatest cold, both North and South.

Q. What other reason is given why the one is positive and the other negative.

A. Because the torrid regions receive the rays of the Sun more vertically than the other.

Q. What application can be made of this infallible rule?

A. The equatorial regions being positive and the polar being negative, there is a mutual attraction of the positive, or the superabundant fluid of the one and the negative of the other.

Q. Upon what principle is this clearly understood?

A. On the immutable and universal chemical principle, viz.: that opposite properties, or a positive and a negative, always attract, or that coloric always seeks to keep up an equilibrium, or to restore it when disturbed.

Q. What is the result?

A. That there are actually two forces operating upon the superabundant electricity or caloric of the equator.

Q. What is then the consequence of the combined action of the two forces?

A. Why, there will be two strong currents of electricity rushing continually with lightning speed form the points of the greatest cold, or the magnetic poles, instead of the geographic poles, to the equator.

Q. Now, will you give us an explanation of magnetic attraction?

A. It is evident that currents of electricity influence the needle, and the reason why the North Pole guides the needle north of the equator and the South Pole, when south of the equator, is, that these currents of electricity, rushing from the poles upward, constitute what is called terrestrial magnetism.

Q. What effect do these currents have upon the needle?

A. They give direction to the needle of the compass, and, as the point of the greatest cold varies,

so these currents vary, and as they vary, so the needle varies.

Q. Were the geographic pole of the Earth the point of attraction, what effect would it have on the needle?

A. It would never vary at all, but as it is, it varies both diurnally and annually.

Q. Why is this so?

A. Because there are causes always operating at the North Pole to change the point of the greatest cold, particularly in the summer season, when the floating icebergs or ice islands of the Arctic are continually changing their position.

NOTE. — There are other hitherto mysterious phenomena which can be rationally and philosophically accounted for only on the supposition that such currents of electricity exist, as we have described.

LESSON LX.

AURORA BOREALIS.

ANALYSIS.— How produced — Caloric and Electricity the same — Currents within the Earth naturally seek the point of the greatest cold, flow out and form a lambent waving light — Called Aurora — This illustrated — Historic evidence — Captains Parry and Ross — Their testimony — The ultimate conclusion — This clearly explained — Power of Terrestrial Magnetism controls the Moon — On the principle of Attraction and Repulsion — The same law by which the Sun governs the Planets and they their Secondaries in the Solar System.

Q. How are the phenomena of the Aurora Borealis and Aurora Australis, the Northern and Southern Lights, produced?

A. Now, if caloric and electricity be the same, of which there is no doubt, then these currents, issuing from within the Earth, naturally seek the point of the greatest cold, in the frigid zone.

Q. When it arrives at that point, what becomes of this electric fluid?

A. It streams up into the rarer regions of the atmosphere, and, in its return to its original source, it spreads out into the lambent, waving light, exhibited by Aurora.

Q. How is this illustrated?

A. The appearance being precisely the same as electricity exhibits in passing through an exhausted tube — the same cause — the rarity of the atmosphere, operating in both cases, to produce a luminous, waving cloud, which proves that they must be identical.

Q. What historic evidence have we that these positions are tenable?

A. Captains Parry and Ross, in their expedition to discover the North-west passage, ascertained that the focal point from which streams upward the Aurora Borealis, was exactly the point of magnetic attraction.

Q. What conclusive evidence did they obtain?

A. That when drawing near that point, the dipping needle stood exactly perpendicular, while the horizontal needle would not traverse at all, but would remain in any position in which it was placed.

Q. What other important fact did they discover?

A. They ascertained also, what we have heretofore maintained, that this point of attraction was comparatively that of the greatest cold.

Q. From this investigation and this course of reasoning, what is the ultimate conclusion?

A. That caloric streams down from the Sun, deeply electrifies the equatorial regions, penetrates the Earth, rendering it entirely magnetic, and that its internal magnetism seeks an egress through the points of the greatest cold, streams upwards as it passes out from the magnetic poles, rises into the rarer or thinner regions of the atmosphere, and, like electricity in its passage through the exhausted tube, spreads out into a waving, luminous cloud, and forms the Aurora Borealis at the north, and the Aurora Australis at the south.

Q. How is it that the Earth holds the moon steady in its orbit, while revolving around it?

A. The Earth, having been made a magnet by the electrical power of the great galvanic battery, the Sun, now by its terrestrial magnetism, controls the moon in its revolution, on the principle of attraction and repulsion, the same law by which the Sun governs all the planets and they their secondaries in the Solar System.

LESSON LXI.

Attraction and Repulsion.

Analysis.— Subject defined — Law governing — Ultimate particles have opposite polarities — Law manifest — Laws of the whole are the laws of its parts — By this rule only can Attraction and Repulsion be accounted for — Magnetism and Electricity considered the same agent — Galvanism differs only in the mode of exhibition — Experiment — Result from passing a current of Galvanism through Soft Iron; change the poles of Battery — Change the polarity of the Iron — This explained — Distinction of polarity manifest in the direction of the current — This explained — Positive and negative end to every thing — Running electricity — The inward current always negative — The outward current positive — Remark.

Q. Now, what is the solution of the apparent difficulty?

A. It is this, every ultimate particle of electricity has opposite polarities, that is, each end of each individual particle has a different property; like ends, or polarities, repel, and unlike ends or polarities attract.

Q. What immutable truth is clearly evident from this position?

A. That the laws of the whole are the laws of its parts.

Q. By the operation of this rule, what phenomenon can be rationally accounted for?

A. The phenomenon of Attraction and Repulsion among both atoms and planets.

Q. What is the difference between electricity and galvanism?

A. They are generally conceded to be the same agent — galvanism differs only in the mode of its exhibition.

Q. What is the result if you pass a current of galvanism around soft iron, bent in the shape of a horse shoe, wound with insulated copper wire?

A. You make the iron magnetic, and the two ends have different polarities.

Q. What is meant by different polarities.

A. That one is negative and the other positive, or, what one end attracts, the other will repel.

Q. Suppose we change the poles of the battery, and pass the current of electricity in the opposite direction around the spiral wire, what will be the result?

A. There will be a change in the polarity of the iron, and make the end that was positive, negative, and the end that was negative, positive.

Q. How can this be clearly shown?

A. It can be shown by experiments in electro-magnetism.

Q. Upon what, then, does a positive and negative state evidently depend?

A. They entirely depend upon the direction in which the current runs.

Q. What distinction of polarity is manifest in the direction of the current?

A. The end, where the current passes inward, is always negative, and the end where it passes outward, is always positive.

Q. What reason have we for this phenomena?

A. It is readily found in the admirable rule "that the laws of the whole are the laws of its parts."

Q. If by running a current of electricity in a certain direction, we make one end of a bar of iron positive and the other negative, what must be the polarity of each individual particle?

A. Each particle must have a positive and a negative end.

Q. In the passing of the current, how are we to distinguish the polarity?

A. The positive end is always leading, and the negative, of course, always following.

Q. Why should we naturally infer this?

A. From the fact that the laws of the whole are the laws of its parts, and the laws of its parts are the laws of the whole.

Remark. — It would be utterly impossible that the whole of a thing should have a quality the opposite of the parts of which it is composed.

LESSON LXII.

Attraction and Repulsion — Continued.

Analysis.— Another mode of illustration — Current of Galvanism passed around Steel — Result — A magnet — Cut the Steel in pieces — Each arranged with the same polarity of the whole — Logical inference — Conclusively evident — How illustrated — By the atmosphere and ocean.

Take Another Illustration.

Q. Suppose we pass a current of galvanism around a bar of steel, spirally, in the same manner it is passed around soft iron, what will be the consequence?

A. We make it permanently magnetic, the end where the current enters is negative, and the end that is outward is positive, and so it will remain for years.

Q. Now should we cut that bar of steel in ten thousand pieces, what would be the polarity of each piece?

A. Each piece would have a positive and a negative end, and the positive and negative polarities of the pieces will be arranged in the same direction as in the whole.

Q. What then is the unavoidable and logical inference?

A. That each ultimate particle of electricity which made it magnetic and kept it magnetic has opposite polarities, as well as the whole current.

Q. Why is this conclusively evident?

A. Because the polarities of the whole are most assuredly made up of the properties of its parts.

Q. How may this be clearly illustrated?

A. A mere thimble-full of atmosphere contains its proportion of oxygen and nitrogen, as well as the whole mass. A drop of water contains its

relative proportion of oxygen and hydrogen as well as the ocean — and so with every thing else.

Remark. — The question as to what is the real cause of attraction and repulsion is one that has not been clearly understood, and hence has not heretofore been satisfactorily explained.

Electricity has been esteemed so mysterious and complicated in its operations that there has been a hesitancy to investigate its laws, or, if such investigation has been made, there has been a reluctance to express the opinions entertained respecting them, for fear those opinions would become a subject of ridicule to the Scientific World. These laws, when fully understood, clear up the mystery.

LESSON LXIII.

Attraction and Repulsion — Continued.

Analysis.— This theory explained — Two magnets — Effect when Positive and Negative are presented to each other — They attract — Result when like polarities are presented — Entirely opposite; they now Repel each other — Two *Positives* repel — A *Positive* and *Negative* attract each other — Scientific World challenged to give a clear explanation on any other principle — A body charged with electricity has an outward current, and will attract a negative with an inward current — Clearly shown by the magnets — These laws applied in the Attraction and Repulsion — How accomplished.

Q. Our first inquiry is, will not the above theory explain the phenomena of attraction and repulsion?

A. We think the facts above stated are true, and can be fully and satisfactorily illustrated.

Q. How can this principle be easily and scientifically explained?

A. Take two steel magnets, with equal power, let them be dipped in iron filings until they have accumulated as large an amount as they can retain upon their poles, and the opposite poles of each be presented within a short distance of each other, the filings will spin out and fill up the space between them, and present an oily, ropy appearance.

Q. What will be the consequence if we change and let like poles be presented?

A. Then the filings will be blown back, as it were, and stand out like hair around the points of the magnets.

Q. Now what does this indicate?

A. It shows that there is attraction in the former case and repulsion in the latter.

Q. Does not the admission of this principle and its explanation show conclusively that electricity must be the controlling power in attraction and repulsion?

A. We cannot see how "*two positives repel, and a positive and a negative attract,*" can be explained on any other principle, and challenge the *Scientific World* to give another.

Q. Why is it that a body charged highly with electricity, has an outward current, and will attract one that is negative, with an inward current?

A. Because it has been shown by the magnets that the body thus charged always presents its positive end, and the body, negative, with an inward current, is attracted, and presents its negative end to the positive.

Q. What is clearly indicated by this representation?

A. That these two bodies, one having an out-

ward and the other an inward current, present opposite polarities to each other, and are attracted from the immutable law, that opposite polarities attract.

Q. Now suppose we apply these laws of attraction and repulsion, as exhibited by the magnets, to the planets?

A. We have a correct solution of the apparent difficulty.

Q. How is this accomplished?

A. The Sun, being positive, pouring a flood of light upon one portion of a planet, soon renders that portion positive, hence, is repulsed by the Sun, while the other portion, being negative, is attracted by the Sun, thus clearly illustrating the principle of repulsion and attraction, by the unchangeable law that two positives repel, and a positive and negative attract each other.

INSTRUCTION TO THE TEACHER IN THE USE OF THE DIAGRAM AND IN POINTING OUT AND EXPLAINING THOSE PRINCIPLES THAT PERTAIN TO THE MOTION OF THE PLANETS.

I.

In teaching, the teacher should have the pupils recite in concert the Tabular view.

When they become familiar with that, then point to any planet in the Solar System, and ask how far that planet is from the Sun. Soon as they observe where the teacher points, and sees the name of the planet, they will know how far it is from the Sun; having learned it in the Tabular Table, at the same time they can see the Sun, as the grand center, around which the planets moved. This enables the pupil to associate the idea with the form, and conceive in his mind distance.

II.

The teacher, as he asks the questions laid down in the lesson, will point to the planet about which he is asking questions.

III.

When he speaks of the distance the planet is from the Sun, he will convey to the mind of young scholars a more clear idea of distance by moving his pointer from the Sun to the planet of which he speaks.

IV.

When he asks how long it takes a planet to make a revolution around the Sun, he should hold his pointer even with the axis of the planet, inclined in the same way with it; and as he moves it around the Sun from west to east, he gives an idea of yearly motion.

V.

In showing the cause of equal day and night, the teacher will show the pupil how the Earth is represented in the Diagram on the 21st of March and the 23d of September. Show him that the Sun then strikes vertical at the equator, and shines from pole to pole, illuminating the whole side of the Earth, while the side from the Sun is dark, as represented in the Diagram.

VI.

Then to show why the days grow longer and the nights shorter, he can illustrate it from the Diagram, that as the Earth moves from her place in March to the one she occupies in June, the north polar circle is advancing further into the light, and the south polar circle is receding into the dark, to a corresponding extent, at the same time. Then, by holding the pointer parallel with the equator, the part of the Earth above the pointer will show how

much of the Northern Hemisphere is enlightened, and the part below the pointer will show how much of the Southern Hemisphere is enlightened, so that when the days are growing longer north of the equator, they are growing shorter south of the equator; and while the days are growing shorter in the Northern Hemisphere, they are growing longer in the Southern Hemisphere; the same may be shown of the nights.

VII.

The teacher will give a correct idea to the pupils why it is winter in the Southern Hemisphere while it is summer in the Northern, by placing his pointer parallel to the equator, so as to show that a great part of the Northern Hemisphere is continually in the light of the Sun, while at the same time so little of the Southern Hemisphere is enlightened.

VIII.

Again, he can show by placing his pointer on the equator in the same way as before, that the inhabitants south of the equator have the same season of the year that we have north, when the Earth arrives in the exact opposite point of the orbit. For instance, on the 21st of December they have the same season that we do when the Earth reaches that point of her orbit designated as on the 21st June, for in every opposite point of the Earth's orbit, the same is represented in the Diagram, showing as much enlightened north of the equator as is enlightened in the opposite point of the equator.

ECLIPSE.

In explaining the causes of an eclipse, the teacher can show by his book or his pointer, its shadow. The pupil will perceive that a body always casts its shadow in the opposite direction from the light.

Then as the Sun is the great source of light, the Earth is represented as casting her shadow in the opposite direction from the Sun.

IX.

The Diagram represents the moon in the Earth's shadow, which causes it to be eclipsed. The teacher will be particular to show the pupils the manner in which the Moon is enlightened by the Sun, and that the rays of incidence and reflection are in equal angles; so that rays of light from the Sun that strike upon the moon are reflected to the Earth in like angles, causing the side of the moon toward the Earth to show a constantly expanding crescent from new till full moon, then a continuous wane, till no rays from the Sun can be reflected to the Earth from the moon, as she is at new moon, between the Earth and the Sun.

X.

The teacher will point out the path or orbit in which the Earth moves around the Sun, and show them that its circumference is 600,000,000 miles, and as the Earth flies through this space once every year, in the period of one month she will move one-twelfth of 600,000,000 miles, which is 50,000,000, and the north polar circle has advanced a little further into the light, from the 21st of March, as represented in April on the Diagram; and by holding his pointer just as the axis of the Earth is inclined, and passing it along round toward June, can show how many million miles the Earth moves from her place in March, before the north polar circle is wholly in the light and the south polar circle is entirely in the dark, which is

150,000,000 miles, and as the axis points always in the same direction in the heavens, of course the south pole will remain in the dark while the Earth moves 150,000,000 miles still further, showing why we have six months day at the north pole, and night during the same time at the south pole. Then the south pole begins to come into the light, and remains in it from the 23d of September until the 21st of March, and the north pole is in the dark during the same time, showing why we have in turn six months day at the south pole, and night during the same time at the north pole.

XI.

Reference to the diagram should be made whenever the teacher can associate an idea with the form, especially with the beginner in the study of Astronomy, for nothing is better calculated to call forth and develop the reasoning faculties of the young scholar than to associate ideas with forms.

XII.

Again, these principles that pertain to the motions of the Earth are principles that prompt the first inquiry of the pupil, and are most difficult of explanation by the teacher.

XIII.

It is not only important that the education the youth receives should be virtuous and purely moral, flowing from well cultivated minds, but it is equally important that it should be correct, and an occular demonstration will render those principles clearer to young scholars, without which their imagination cannot be stretched to make them understand without going beyond their capacity.

APPENDIX.

TABLE I.—ELEMENTS OF THE SOLAR SYSTEM—(SUN'S PARALLAX, 8.94″).

NAME.	Mean Diameter.	Oblateness.	Mass, Earth being one.	Density compared with Water.	Mean Distance in Millions.	Eccentricity of Orbit.	Inclination of Orbit.	Sidereal Period. Years.	Sidereal Period. Days.	Synodic Period. Days.	Time of Rotation.	Inclination of Axis.
SUN.....	852,900		315,000	1.42	.....	.....	.....	....	.....	.....	25 d. 8 h.	7° 20′
MERCURY,	2,962	?	.063	6.86	35.4	.205	7°	....	88	116	23 h. 56 m.	.....
VENUS ...	7,510	?	.885	5.84	66.15	.0069	3½°	....	224⅝	584	23 h. 21 m.	75°
EARTH....	7,912	1/299	1.	5.67	91.5	.017	.....	....	365¼		24 h.	23° 28′
MARS.....	4,300	1/50	.118	3.97	139.3	.093	1°51′	1	322	780	24 h. 37 m.	28° 42′
JUPITER..	85,000	1/17	301.	1.37	475.75	.048	1°19′	11	315	399	9 h. 55½ m.	3° 6′
SATURN...	70,100	1/10	90.	.74	872.	.056	2°30′	29	167	378	10 h. 29 m.	26° 49′
URANUS ..	33,247	1/10	12.65	.97	1,754.	.047	46½′	84	6	369½	.....	.....
NEPTUNE.	36,806	?	16.8	.91	2,746.	.0087	1°47′	164	226	367½	.....	.....
MOON	2,162		1/80	3.4	.2388	.055	5¼°	....	27⅓	29½	27⅓ d.	6° 39′

TABLE II.—ELEMENTS OF THE MINOR PLANETS.

NAME.	Number.	Mean Distance. Earth's=1	Eccentricity.	Inclination of Orbit. °	′	Sidereal Period. Yrs.	Dys.	Discoverer.	Date.
FLORA.....	8	2.2014	.157	5	53	3	97	Hind.....	1847
ARIADNE.....	43	2.2034	.168	3	28	3	99	Pogson.....	1857
FERONIA	71	2.2661	.12	5	24	3	150	C. H. F. Peters.....	1861
HARMONIA.....	40	2.2677	.046	4	16	3	151	Goldschmidt.....	1856
MELPOMENE	18	2.2956	.217	10	9	3	174	Hind.....	1852
SAPPHO	80	2.2963	.2	8	37	3	175	Pogson	1864
VICTORIA.....	12	2.3344	.219	8	23	3	207	Hind.....	1850
EUTERPE.....	27	2.3467	.173	1	35	3	217	Hind.....	1853
VESTA	4	2.3733	.09	7	8	3	229	Olbers.....	1807
URANIA	30	2.3655	.126	2	6	3	223	Hind.....	1854
NEMAUSA.....	52	2.3657	.066	9	57	3	223	Laurent	1858
CLIO	84	2.3675	.238	9	22	3	225	Luther	1865
IRIS.....	7	2.3862	.231	5	28	3	240	Hind.....	1847
METIS.....	9	2.3866	.123	5	36	3	251	Graham	1848
ECHO.....	62	2.393	185	3	34	3	256	Ferguson.....	1860

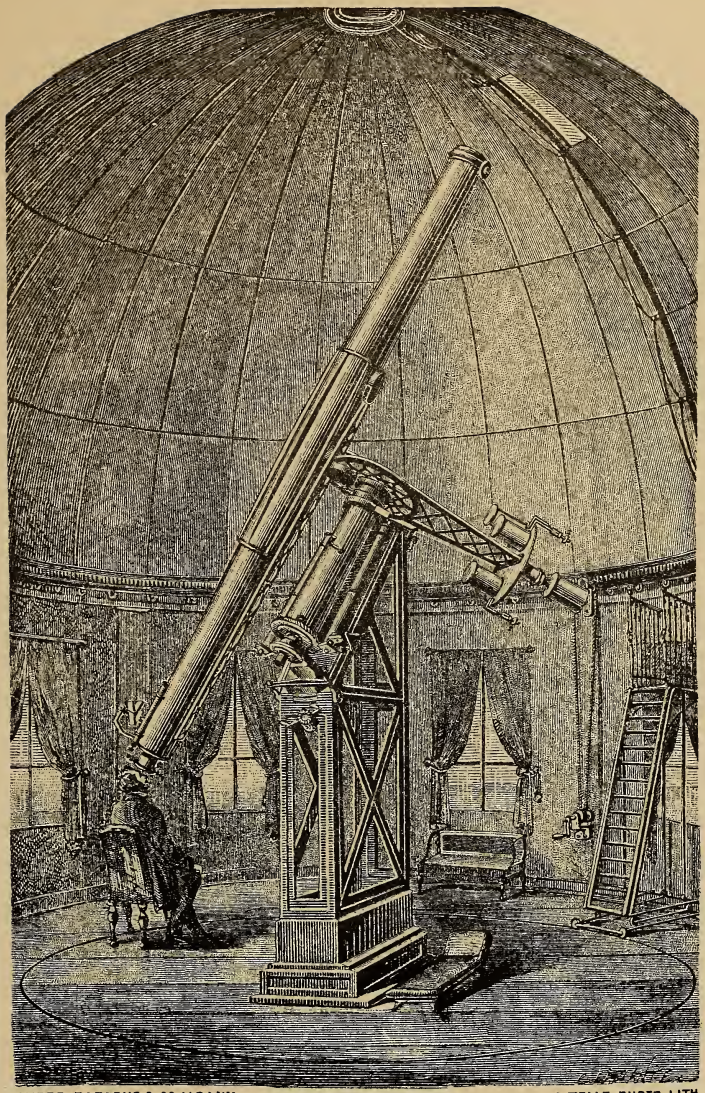
TABLE II. — ELEMENTS OF THE MINOR PLANETS — Continued.

Name.	Number.	Mean Distance.	Eccentricity.	Inclination of Orbit.		Sidereal Period.		Discoverer.	Date.
		Earth's=1		°	′	Yrs.	Dys.		
Ausonia	63	2.395	.126	5	47	3	258	De Gasparis	1861
Phocea	25	2.4008	.254	21	35	3	263	Chacornac	1853
Massilia	20	2.4097	.144		41	3	270	De Gasparis	1852
Asia	67	2.4217	.185	5	59	3	280	Pogson	1861
Nysa	44	2.422	.151	3	42	3	281	Goldschmidt	1857
Hebe	6	2.4259	.203	14	47	3	284	Hencke	1847
Beatrix	83	2.4287	.084	5	2	3	287	De Gasparis	1865
Lutetia	21	2.4354	.162	3	5	3	292	Goldschmidt	1852
Isis	42	2.44	.225	8	34	3	296	Pogson	1856
Fortuna	19	2.4411	.158	1	33	3	297	Hind	1852
Eurynome	79	2.4431	.195	4	37	3	299	Watson	1863
Parthenope	11	2.4519	.099	4	37	3	306	De Gasparis	1850
Thetis	17	2.4735	.128	5	36	3	325	Luther	1852
Hestia	46	2.5265	.164	2	18	4	6	Pogson	1857
	89	2.5498	.18	16	11	4	26	Stephan	1866
Amphitrite	29	2.554	.074	6	8	4	30	Marth	1854
Egeria	13	2.5766	.087	16	31	4	50	De Gasparis	1850
Astræa	5	2.5771	.187	5	19	4	51	Hencke	1845
Irene	14	2.586	.166	9	8	4	58	Hind	1851
Pomona	32	2.5873	.083	5	29	4	59	Goldschmidt	1854
	91	2.5958	....	.....		.....		Stephan	1866
Melete	47	2.5959	.237	8	1	4	67	Goldschmidt	1857
Panopea	70	2.6133	.183	11	38	4	82	"	1861
Calypso	54	2.6197	.204	5	7	4	88	Luther	1858
Diana	78	2.6228	.205	8	38	4	90	"	1863
Thalia	23	2.6271	.232	10	13	4	94	Hind	1852
Fides	37	2.6414	.177	3	7	4	107	Luther	1855
Eunomia	15	2.6437	.187	11	44	4	109	De Gasparis	1851
Virginia	51	2.6491	.287	2	48	4	114	Ferguson	1857
Maia	66	2.6512	.158	3	4	4	116	H. P. Tuttle	1861
Io	85	2.6536	.191	11	53	4	118	Peters	1865
Proserpine	26	2.6561	.087	3	36	4	120	Luther	1853
Clytie	73	2.6666	.043	2	25	4	129	Tuttle	1862
Juno	3	2.6684	.257	13	1	4	131	Harding	1804
Eurydice	75	2.6698	.307	5	0	4	133	Peters	1862
Frigga	77	2.6719	.136	2	28	4	134	"	"
Angelina	64	2.6809	.128	1	20	4	142	Tempel	1861
Circe	34	2.6863	.107	5	26	4	147	Chacornac	1855
Concordia	58	2.7003	.042	5	2	4	160	Luther	1860
Alexandra	55	2.7123	.197	11	47	4	171	Goldschmidt	1858
Olympia	60	2.7181	.117	8	37	4	172	Chacornac	1860
Eugenia	45	2.7212	.08	6	35	4	179	Goldschmidt	1857
Leda	38	2.7401	.155	6	58	4	196	Chacornac	1856
Atalanta	36	2.7461	.301	18	42	4	201	Goldschmidt	1855
Niobe	72	2.7554	.174	23	19	4	209	Luther	1861
Pandora	56	2.7591	.145	7	14	4	213	Searle	1858
Alcmene	82	2.7603	.226	2	51	4	214	Luther	1864
Ceres	1	2.7667	.08	10	36	4	220	Piazzi	1801
Lætitia	39	2.7671	.115	10	22	4	221	Chacornac	1856
Daphne	41	2.7691	.266	15	59	4	223	Goldschmidt	"
Pallas	2	2.7696	.24	34	43	4	223	Olbers	1802
Thisbe	88	2.7702	.165	5	15	4	224	Peters	1866
Galatea	74	2.7777	.238	3	59	4	231	Tempel	1862
Bellona	28	2.7785	.15	9	21	4	232	Luther	1854
Leto	69	2.7804	.188	7	57	4	233	"	1861
Terpischore	81	2.8563	.212	7	55	4	302	Tempel	1864
Polyhymnia	33	2.8641	.339	1	56	4	309	Chacornac	1854
Aglaia	48	2.8812	.132	5	0	4	325	Luther	1857
Calliope	22	2.9107	.098	13	44	4	353	Hind	1852
Psyche	16	2.9237	.135	3	4	5	...	De Gasparis	"
Hesperia	68	2.9717	.174	8	28	5	45	Schiaparelli	1861
Danae	59	2.9848	.162	18	15	5	57	Goldschmidt	1860

TABLE II. — ELEMENTS OF THE MINOR PLANETS — CONTINUED.

Name.	Number.	Mean Distance.	Eccentricity.	Inclination of Orbit.		Sidereal Period.		Discoverer.	Date.
		Earth's=1		°	′	Yrs.	Dys.		
Leucothea	35	3.0066	.217	8	12	5	78	Luther	1855
Pales	50	3.0825	.237	3	9	5	150	Goldschmidt	1857
Semele	86	3.0908	.205	4	48	5	158	Tietjen	1866
Europa	53	3.0999	.004	7	25	5	168	Goldschmidt	1858
Dorispe	49	3.1094	.077	6	29	5	176	"	1857
Antio	90	3.1188	.148	2	16	5	186	Luther	1866
Erato	61	3.1297	.169	2	12	5	196	Forster	1860
Themis	24	3.1431	.117		49	5	209	De Gasparis	1853
Hygeia	10	3.1511	.1	3	49	5	217	"	1849
Euphrosyne	31	3.1527	.22	26	27	5	218	Ferguson	1854
Mnemosyne	57	3.1565	.104	15	8	5	222	Luther	1859
Freia	76	3.3877	.188	2	2	6	86	D'Arrest	1862
Cybele	65	3.4205	.12	3	28	6	119	Tempel	1861
Sylvia	87	3.4927	.....	.....		6	193	Pogson	1866
Minerva	92	.....	.....	.....		.....		Watson	1867
Undina	93	.....	.....	.....		.....		Peters	"
Aurora	94	.....	.....	.....		.....		Watson	"
Arethusa	95	.....	.....	.....		.....		Luther	"
Ægina	96	.....	.....	.....		.....		Borelly	1868
Clotho	97	.....	.....	.....		.....		Tempel	"
Ianthe	98	.....	.....	.....		.....		Peters	"
Hecate	99	.....	.....	.....		.....		Tempel	"
Helena	100	.....	.....	.....		.....		Watson	"
Names not Given.	101	.....	.....	.....		.....		"	"
	102	.....	.....	.....		.....		Peters	"
	103	.....	.....	.....		.....		Watson	"
	104	.....	.....	.....		.....		"	"
	105	.....	.....	.....		.....		"	"
	106	.....	.....	.....		.....		"	"

PLATE XX.



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